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Established Over 30 Years

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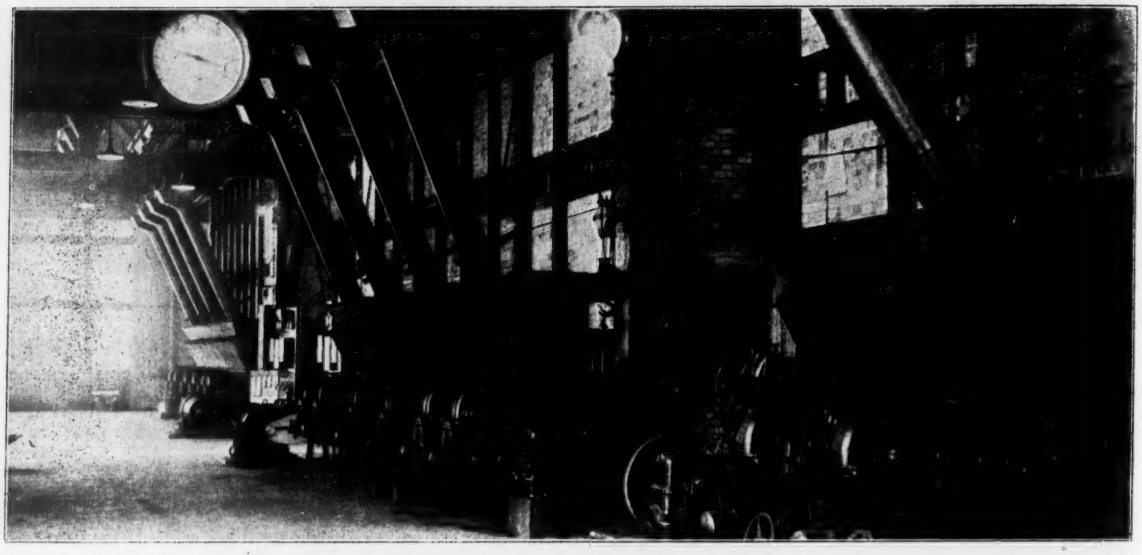
Sea-Going Spider Webs

FAR OUT AT SEA, the fisherman sometimes finds floating in the air a few gossamer strands from a spider's web. How they get there no one knows, but the fisherman, when he sees them, usually remarks, "Wa-all, guess we'll have a spell o' weather." And he's usually right. Anyway, the spider web shown above is certainly sea-going, for it has been spun about the derrick on the Monarch, second largest marine derrick in the world. Can you see the spider, lowering himself by that slender strand that he spins out of his own body?

If you must know, however, the object that the derrick is picking up is an armature for a 40,000-kv.a. frequency changer now being installed at Hell Gate Station to tie together the 25 and 60-cycle systems of the New York Edison Co. and the United Electric Power Co. This armature weighed 226,000 lb. or 113 t. and measured 13 ft. in diameter and 20 ft. in length. In order to ship it by rail from the plant of the General Electric Co., at Schenectady, where it was made, it had to be mounted on a special car, the yard gates had to be removed and the Delaware & Hudson Railroad track cleared of trains on both sides all the way to Albany.

At Albany it was taken to a dock where the Monarch, one of the marine derricks used in the attempt to raise the sunken submarine S-51, unloaded it onto her deck. It was then taken to New York by water.



Toledo Edison Increases Capacity of Acme Plant

ADDITION OF FOUR 18,000-SQ. FT. BOILERS AND AUXILIARIES, TOGETHER WITH STAGE HEATERS TO IMPROVE HEAT BALANCE, ENABLES TURBINES TO OPERATE AT FULL LOAD. BY E. A. DOERR*

EARLY IN THE SPRING of 1916 an addition was started to take care of the increased load for the Toledo Railways & Light Co. The old plant was located in the heart of the downtown district of Toledo and had expanded to its extreme capacity. It was decided to start in on a new site on the east side of the river. This part of the plant, known as the Acme Plant, was completed in the fall of 1917 and at that time was equipped with two 20,000-kw. General Electric three-phase 25-cycle steam turbines complete with Wheeler Condenser & Engr. Co. surface condensers and equipment. Steam to these two units was supplied by four 1375-hp. Bigelow-Hornsby boilers and four 1450-hp. Babcock & Wilcox boilers. These boilers were equipped with Taylor underfeed stokers; flue gas was passed through Sturtevant economizers to three 250-ft. radial brick stacks. This part of the plant was designed to take an additional turbo-generator, which was installed in 1922, this unit being a 30,000-kw. three-phase, 25-cycle Westinghouse turbine complete with Wheeler Cond. & Eng. Co. surface condenser and auxiliaries. This made the turbine capacity of the plant 70,000 kw. but, due to limited boiler capacity, the load on this plant was held to approximately 50,000 kw.

*Engineer, Power Production Dept., Toledo Edison Co.

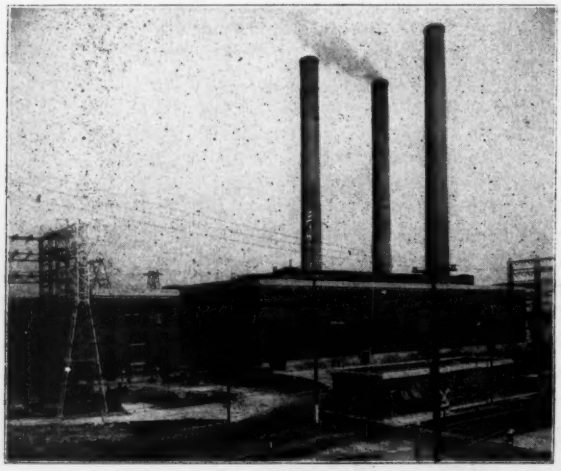


FIG. 1. ACME PLANT AS IT APPEARS AT PRESENT

This plant, known as the Acme Plant, operates on 25-cycle current due to the 25-cycle load which is handled in and about Toledo. It was necessary, however, to install a frequency changer later, so that tie-ins with other power generating companies could be made; it is planned eventually to continue this station with 60-cycle generation due to tying in with outside surrounding towns. During this period the old plant of the Toledo Railways & Light Co., which had now become the Toledo Edison Company, was used to take care of peak loads and also for standby operation. Operating costs under this plan were high and it was finally decided to install additional boiler capacity at the new station so that the old plant could be abandoned. Work on this addition started early in 1925 and the first boiler was put in operation in November of the same year. Figure 1 shows the station and the headpiece above is a general view in the boiler room addition that will be described here.

COAL HANDLING EQUIPMENT

Coal is received at Acme Plant in carload lots over a branch of the Pennsylvania Railroad. It is either put in stock by locomotive cranes or is dumped direct into concrete receiving hoppers and picked up by overhead crane and dropped into the receiving hopper over the conveyor. It is here picked up by a short cross conveying belt and, after passing over a Dings 30-in. magnetic pulley, drops direct into a 24 by 60-in. armorframe Pennsylvania single roll crusher. The tramp iron is

bypassed into a small receiving hopper and is removed by hand to storage. The coal, after passing through the crusher, goes on a 24-in. Robins belt conveyor to the concrete bunker over boilers. During normal operation the coal passes from bunkers to an oscillating system of spouts to the stoker hopper.

Scales are provided for weighing coal between hopper and spouts during test runs; a Merrick Conveyor Weightometer records coal put into bunkers daily. Ash is removed in standard railroad cars. Figures 2 and 3 show the general coal and ash handling arrangement.

Boilers, Stokers and Accessories

Four 18,000-sq. ft. Bigelow-Hornsby, six-unit boilers were installed, the last two units acting as integral economizer sections. These boilers are designed for 276 lb. working pressure with 14,643 sq. ft. of heating surface in each boiler proper and 3463 sq. ft. in its economizer section. Stokers are Westinghouse 16-retort underfeed units, with steam operated agitator and double roll clinker grinders. Each stoker is driven by a 7-hp. d.c. motor with speed controller.

Four motors, one to each stoker, are permanently connected, while a fifth motor, mounted on a movable platform, is provided to operate any one of the four stokers in an emergency. Clinker grinders are driven by two 4-hp. motors per stoker with adustable speed by field control. Four porthole lights have been in-

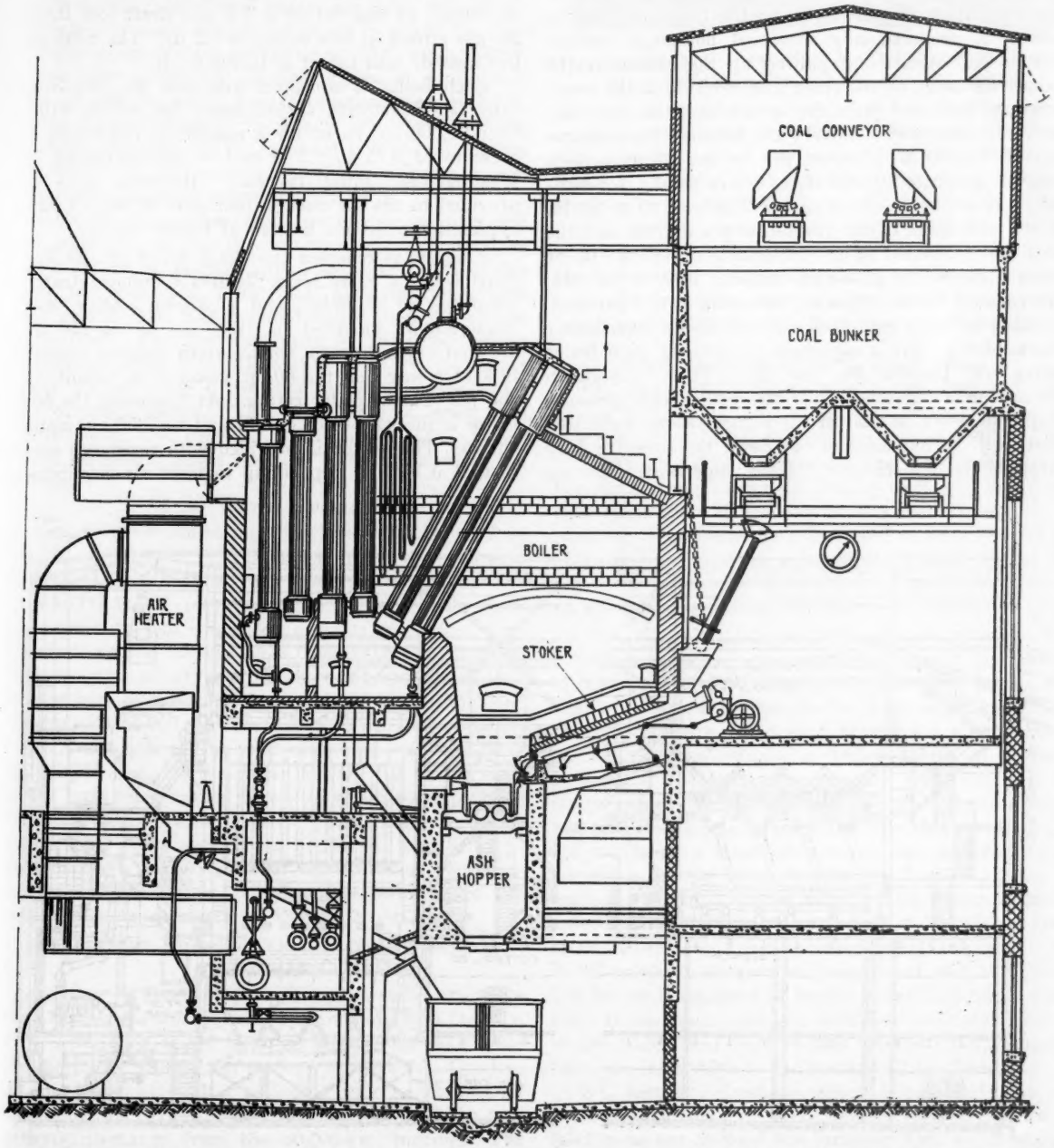


FIG. 2. SECTION THROUGH ONE OF THE NEW BOILERS, SHOWING COAL AND ASH HANDLING ARRANGEMENTS AND AIR PREHEATER

stalled under stokers so that operators can locate hot spots during operation. Each stoker is also connected to a De Laval reducing gear set for operation of oscillating spouts. To oscillate these coal spouts a home-made spout swinger is used; part of this device is shown in Fig. 4 and also in the headpiece. The main stoker drive shaft, acting through the reduction gear, slowly rotates a disc carrying a pin at its edge. From this pin a piece of wire rope extends up to a hook on the sheave of a four strand block-and-tackle, as shown. The free end of the tackle, which is of wire rope, runs horizontally over the stoker hopper, over another pulley at the far end, not shown, and has a counter weight on its end. The horizontal strand of the rope is clamped to each coal spout. As the disc revolves, on one half of each revolution it pulls down on the block and tackle, causing a proportionally increased horizontal motion of rope and spouts and pulling up the counterweight a short distance; on the other half revolution, the counterweight falls and pulls the spouts back the same distance the other way. Stokers are designed for evaporation of 180,000 lb. of steam per hr. for 24-hr. periods and will generate 200,000 lb. of steam per hr. for periods of four hours. Each ram will deliver 21 to 22 lb. of coal at a speed of one revolution per minute, and the total coal consumed at an evaporation of 180,000 lb. of steam is 25,360 lb., giving an efficiency of 73.4 per cent. The combustible in refuse at this rating is 10.9 per cent.

Each boiler is equipped with an Elesco superheater guaranteed to give a superheat of 210 deg. at a boiler rating of 180,000 lb. per hr. These superheaters are cross-connected with the boiler with pressure drop regulators, so that at the higher ratings saturated steam will be bypassed to cut down the pressure drop through the superheater. Each superheater has an effective gas heating surface of 3320 sq. ft. The internal or steam-touched surface amounts to 2860 sq. ft. On one of these boilers we are installing a Bailey water-cooled bridge wall, which has been so designed that it will act as a slag screen for the boiler proper. This wall will also add active heating surface to the boiler.

Fans and Air Heaters

Gas from the boilers is passed through Combustion Engineering Co. air heaters of the plate type, 6 ft. by 14 ft. each, with 80 elements to a heater. These heaters are guaranteed to raise the temperature of furnace air to 426 deg. F. at a boiler rating of 180,000 lb. an hr. with inlet air temperature 70 deg. Draft lost through the air circuit at this rating is 3.2 in.; draft lost through the gas circuit at this rating is 1.2 in. The total effective area of each heater is 12,400 sq. ft.

Each boiler is equipped with one No. 140 Sturtevant Co. Turbovane forced draft fan, which will deliver 90,000 cu. ft. of air a minute at 720 r.p.m. at a pressure of 8.75 in. Fan motors are controlled by a Westinghouse liquid rheostat. Bypasses have been provided in the air duct so that part of the air can be bypassed around air heaters at higher ratings.

Flue gas is removed from each boiler by one No. 15 Sturtevant Co. extra heavy Multivane induced draft fan connected to a 50-hp. and a 350-hp., 440-v. motor. These motors, mounted on either end of the fan shaft, are controlled through Northwestern damper regulators in such a way that the 50-hp. motor is in circuit up to 350 per cent of boiler rating. At this point the 50-hp. motor is thrown out of circuit and the 350-hp. motor is cut in. This motor is provided with resistance control so that it can be stepped up to meet air requirements

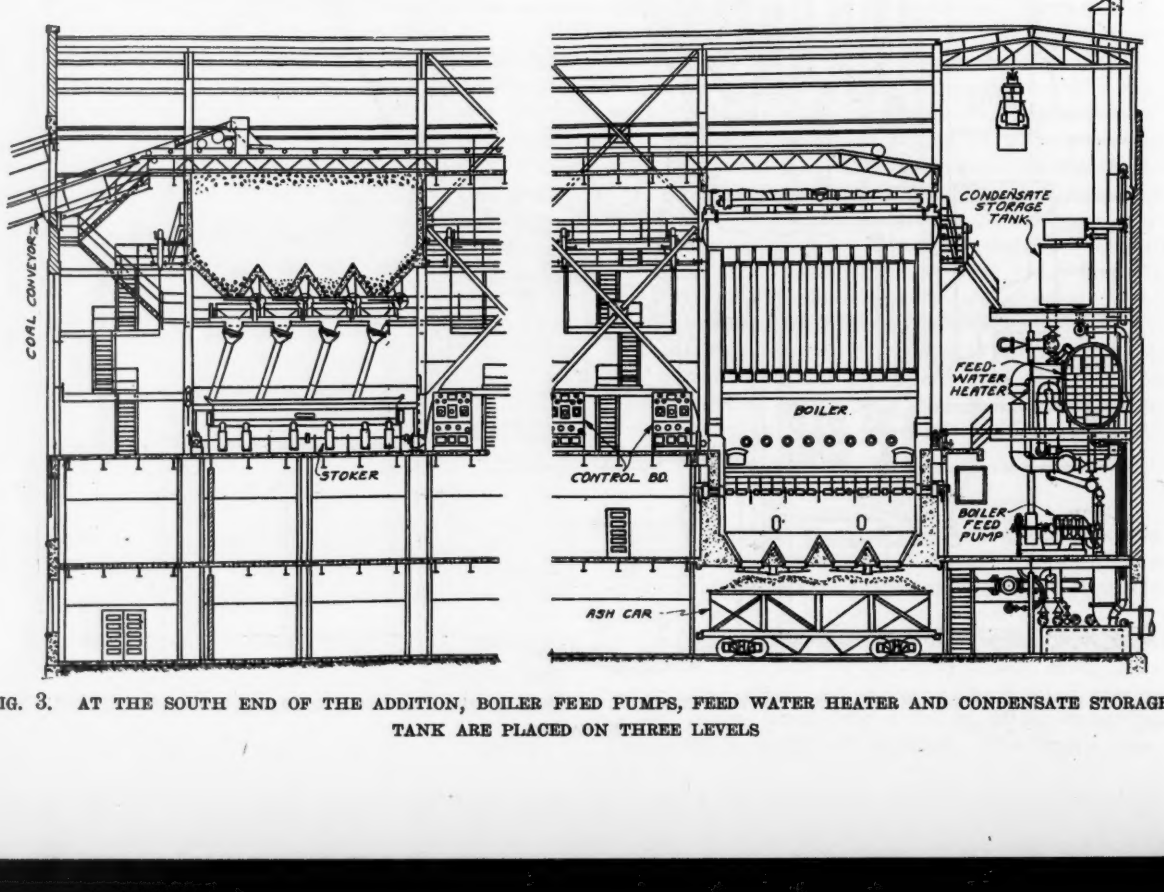


FIG. 3. AT THE SOUTH END OF THE ADDITION, BOILER FEED PUMPS, FEED WATER HEATER AND CONDENSATE STORAGE TANK ARE PLACED ON THREE LEVELS

up to 500 per cent boiler rating. This operation is automatic during normal operation but push button stations have been provided at each instrument board so that hand operation can be used in an emergency. Each fan is capable of handling 176,000 cu. ft. of air per minute at a temperature of 500 deg. F and a pressure of 6.3 in. Boilers are equipped with Diamond valv-in-head soot blowers, 14 units per boiler.

Steam Turbines Drive the Boiler Feed Pumps

The south end of the boiler room addition is constructed with floors at three elevations, as shown in Fig. 3. This provides for overhead condensate storage and feed water heaters, also boiler feed pumps. Two 8-in. Worthington, Jeansville model, four-stage, horizontal, double suction, centrifugal pumps are used, each direct-connected through flexible couplings to a 420-hp., type C Terry steam turbine operating at 1900 r.p.m. These pumps have a capacity of 1500 g.p.m. at a discharge head of 350 lb. and a positive suction head of 12 ft. Under these conditions the pumps will develop a mechanical efficiency of 73 per cent. Both pumps are equipped with S-C regulators which maintain a differential pressure of approximately 35 lb.

Discharge lines from these pumps are so arranged that water can bypass through the high pressure stage heater or can be pumped direct to boilers. When this stage heater is used, differential pressure valves have been provided so that constant boiler pressure will be maintained. This has been done by installing bypass connections with S-C differential pressure regulators which will maintain a constant pressure on the boiler side of stage heater. This takes care of peak load points when the pressure drop through the heater would materially affect the feed water pressure at the boilers.

Feed Water Heaters

On the floor above and just over the boiler feed pumps are located two Cochrane horizontal elliptical deaerating type heaters, each heater having a capacity of 600,000 lb. of water an hour. These heaters are equipped with vent condensers and are guaranteed completely to remove air and gases from 600,000 lb. of water an hour, with an oxygen content not greater than 0.03 cc. per litre of water, while at 750,000 lb. an hour the oxygen content will not exceed 0.05 cc. per litre of water.

It is also guaranteed that with inlet water of from 100 to 120 deg. F., the water leaving the heater shall be the same temperature as that of steam corresponding to the pressure within heaters. Each heater contains 180 heating trays each 11 in. by 24. in., and 576 separating trays, each 6¼ in. by 25 in. Each vent condenser contains 350 sq. ft. of surface made up of 492 tubes, ½ in. in diameter, of 18 gage Muntz metal.

Condensate Storage Tank Takes Condenser Discharge

Located on the floor just above heaters is one plate steel condensate storage tank approximately 25 ft. long, 7 ft. 7 in. wide and 8 ft. 9 in. high. This tank takes the discharge water from turbine condensers. Condensate is passed through a recording weir meter, located on top of this tank, which provides a record of the condensate discharge from the 30,000-kw. turbine. The tank is cross-connected with a similar tank in the older section of the plant.

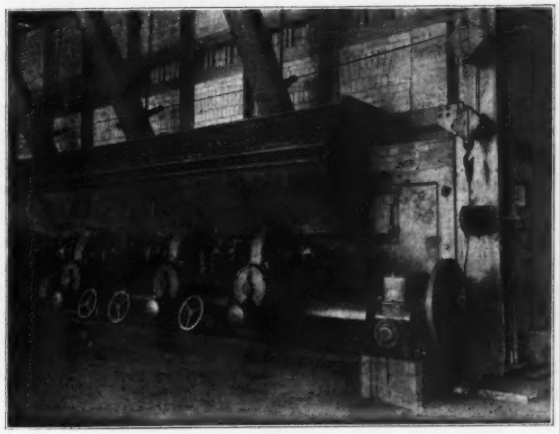


FIG. 4. BLOCK AND TACKLE ARRANGEMENT, DRIVEN FROM MAIN STOKER SHAFT, OSCILLATES COAL SPOUTS

Since condensate from the 30,000-kw. turbine passes through stage heaters and is, therefore, of a higher temperature than that from the other two turbines, balanced check valves were provided between these tanks so that during normal operation the water from this turbine would be utilized for makeup for the new boiler room, the hotter water being particularly beneficial due to the type of economizers used; also because of the increased temperature of the water, these tanks are insulated.

Stage Heaters Improve Heat Balance

To provide for a better heat balance Wheeler Condenser & Eng. Co. stage heaters were installed on No. 1, 20,000-kw. General Electric turbine and also on No. 3, 30,000-kw. Westinghouse turbine. A 12,000-sq. ft. horizontal type extraction heater, arranged for four-pass circulation of feed water was installed on No. 1 turbine. This heater is guaranteed to heat 220,000 lb. of water per hour from a temperature of 92 deg. to 189 deg. when supplied with 23,000 lb. of steam per hour at an absolute pressure of 10.7 lb.

The 30,000-kw. turbine was equipped with one 12,000-sq.ft. horizontal type extraction heater guaranteed to heat 408 lb. of water per hour from 111 deg. to 281 deg. when supplied with 29,450 lb. of steam at 12.5 lb. pressure absolute. A second heater was also installed on this machine containing 18,000 sq. ft. of surface. Because of the higher temperature and superheat of steam entering this heater, a Wheeler desuperheater was provided at the steam entrance. This consists of a hot well with a steam entrance at the side making it necessary for the water leaving the heater to come in contact with superheated steam. This heater is guaranteed to heat 500,000 lb. of water at 30,000-kw. load, from 210 deg. to 269 deg. when supplied with 31,000 lb. of steam at an absolute pressure of 46.5 lb. Since this heater is designed to handle boiler feed water pressure, it has been equipped with S-C regulator control in the boiler feed inlet so that, in case of a ruptured tube, the inlet valve to the heater will be closed.

S-C regulator drainage control is provided; also, on account of the extreme importance of maintaining water level so as not to flood the turbines, high water alarms have been installed. These are of the ball float column type.

Make-Up Boiler and Feed Water Heater

To provide for better operation, it was decided to operate one of the twelve boilers now installed as a make-up boiler. In order to do this, it was necessary to install an additional make-up heater; a Cochrane V-notch metering heater was installed for this purpose. This heater has a capacity of 200,000 lb. per hour and is guaranteed to heat this water from 50 deg. to 210 deg. when supplied with sufficient steam at one pound pressure. One of the old 1000-g.p.m. boiler feed pumps is utilized to handle this water and the four-inch test boiler feed line is at present used as a boiler feed header. As this header was originally connected to all boilers it is possible to utilize any boiler desired for this make-up service.

Piping

Each boiler is provided with a 12-in. Edward non-return valve with a 12-in. connection from boiler to main steam header, which is placed on a pipe gallery on the floor below the boilers and just behind them. All

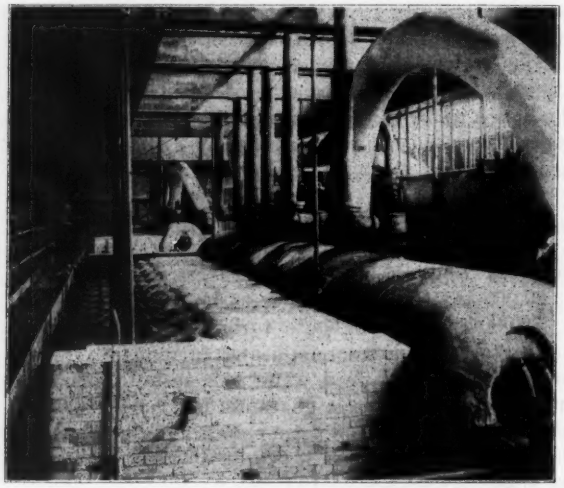


FIG. 5. VIEW AT TOP OF BOILERS SHOWS BOILER DRUMS, SAFETY VALVES AND PART OF MAIN STEAM PIPING

four boiler leads are connected to this header with Chapman electrically operated gate valves and a 20-in. electrically operated Chapman gate valve is provided in the main lead to the turbine and also in the cross connection between turbines No. 2 and 3. These valves are provided with operating stations at the point of control and a remote closing station is provided in the chief engineer's office, the latter station to be used in emergency only.

Two 10-in. boiler feed lines are provided to take care of normal operating conditions. There is, however, an auxiliary 4-in. boiler feed line, used for testing purposes as referred to above. Each boiler is provided with two 5-in. Copes feed water regulators. All flanges are of the tongue and groove type, 400 lb. standard and annealed copper gaskets were used throughout. All joints were made up with special chrome nickel steel bolts, to take care of the high stresses on these joints.

Each boiler is provided with a Bailey boiler meter, type D-25, which records steam flow and air flow; this meter also shows per cent of boiler rating. A Bailey recording type K-5 meter is also provided to show steam pressure, steam temperature, and flue gas temperature.

Bailey multipointer gages indicate draft at various points through the boiler setting and also under the stokers. Ammeters are provided for stoker motors and clinker grinder motors and for forced and induced draft fan motors.

Indicating lamps are provided to show that circuits to various boiler auxiliaries are alive. In case of trouble this gives the operator an indication as to whether the trouble is in his equipment or in the circuit. Meters are located on a boiler room instrument board at each boiler. In addition an illuminated signal board is provided at the end of the boiler aisle which indicates the load on the plant and also whether this load is going up or down. A G. E. electric flow meter located at the end of the firing aisle indicates the flow of steam from this row of boilers. A 30-in. master steam gage is also mounted at the middle of the firing aisle and gives an indication of steam pressure in the main steam header. A heat balance instrument board is provided in the turbine room for operation of stage heaters and boiler feed heaters.

On March 26, 1926, an efficiency test was run on one of the new boilers. This test was run for 8 hr. at an average rating of 364 per cent, which was practically constant over the test period. The overall efficiency of the unit, including the air heater, was 85.14 per cent; without the air heater it was 81.52 per cent.

The following tabulation shows the heat balance of the unit, comprising boiler, superheater, economizer and air heater.

Heat Values	B.t.u.	Per cent
Heat per lb. coal (dry) (higher heating value)	12,902	100.00
Heat absorbed by water and steam in boiler and superheater	10,985	85.14
Heat absorbed by steam in superheater	1154	8.95
Losses		
Heat lost due to combustible in refuse.	259	2.01
Heat loss due to incomplete combustion of carbon	0	0.0
Heat loss due to theoretical dry gases, T_2 to T_8	710	5.51
Heat loss due to moisture in coal, moisture accompanying theoretical air and water from combustion of hydrogen, up to T_8	613	4.75
Heat loss due to excess air and accompanying moisture entering furnace, T_2 to T_8	38	0.29
Heat loss due to air and moisture leaking through boiler setting, T_1 to T_8	82	0.63
Heat loss due to air and moisture leaking through economizer sett., T_1 to T_8		
Heat loss due to air and moisture leaking through air heater setting, T_1 to T_8	98	0.76
Heat loss due to unconsumed hydrogen and hydrocarbons, radiation, and unaccounted for	117	0.91
Air Heater		
Heat available to air heater in flue gases including moisture, T_7 to T_2..	1223	9.46
Heat absorbed by air heater	573	4.26
Efficiency of air heater		46.85

Coal used in the test run was the W. Virginia bituminous that the plant ordinarily burns, with a heating

value of 12,902 B.t.u. per lb. dry. Proximate analysis showed 31.79 per cent volatile, 55.19 per cent fixed carbon, 13.02 per cent ash, 7.98 per cent moisture as fired.

In the furnace, the CO_2 was 15.78 per cent; at the damper, 14.21 per cent; at the air heater outlet, 12.18 per cent. Air entered the air heater at 91 deg., leaving at 309 deg., and entering the stoker compartment at 291 deg.

Flue gas temperature at the damper was 556 deg.; at the air heater outlet, 365 deg.

Design of this plant was by the H. L. Doherty Co., New York City, with G. W. Saathoff as chief engineer; construction work was supervised by E. A. Doerr as field engineer. Operation of plant will be in charge of J. F. O'Connor of the Toledo Edison Co. H. B. Lawrence is superintendent of power production at Acme plant.

Uniform Methods Needed for Comparing Bids

When Buying Equipment, Uniform Method of Evaluation of Competitive Proposals Would Facilitate Comparison. By A. O. Miller*

WITHIN THE LAST few years, the tendency to consider and give proper weight to the performance of turbine-driven generator and pumping units in combination with first costs has been given a marked impetus. More progress in the direction of finding suitable evaluation formulas has been made recently than in the preceding decades. Before the development of the steam turbine and during the height of popularity of the cross-compound and triple-expansion engines, manufacturers were accustomed to state price and steam consumption and purchasers, with a varying degree of exactitude, balanced differences in prices and operating costs one against the other. Many steam engines were sold in that day on the basis of the saving that the salesman could guarantee above and beyond the operating cost of units of a more ancient and less efficient vintage. No comprehensive or uniform method existed of combining first cost and operating expense into a final expression that would accurately and correctly give weight to all factors.

With the development of the more economical steam turbine, which in many cases showed only small differences in the water rates and electrical and hydraulic efficiencies of competing manufacturers, each buyer, manufacturer, public utility or municipal plant operator recognized the desirability of finding a common ground permitting a fair comparison of tenders. The motive actuating the groping for the solution of this problem was, of course, the desire to purchase equipment which would prove the least costly over a number of years of operation representing the reasonable life of the purchased equipment.

Total Cost Involves Fixed and Operating Charges

Total cost of the use and ownership of turbine-driven machinery is composed of fixed and operating charges. Fixed charges, as every engineer knows, consist of: (1) interest on the investment, the amount of which is governed by the prevailing cost of borrowing money; (2) amortization of the plant or an allowance for physical deterioration due to wear and tear, this obsolescence depending on the number of years over which the investment is to be written off; (3) current repair charges necessary to maintain the machinery in perfect operating condition, proportional to the character of the plant and the service it performs; (4) taxes, frequently negligible in the case of municipally-owned plants; (5) insurance.

*American Brown Boveri Electric Corp.

The total of the fixed charges is usually expressed in a percentage of the first cost and may vary from 8 or 9 to 12 or 15 per cent thereof, depending on the values given the above respective component items.

Operating charges, of course, are made up of the cost of fuel, oil, labor and ash handling. When comparing the costs of dissimilar types, wherein the amount of oil and labor varies, these must of necessity be as carefully considered as the cost of fuel. It is evident, however, that in the comparison of units of the same type and size and generally answering to a prescribed set of rigid specifications, the amount for oil, labor and ash removal will be "constant" factors, hence the consideration of these items may well be eliminated with all fairness to the propositions under consideration. The operating charges then resolve themselves into a calculation of the fuel charges. These require the determination of the steam plant's evaporation factor, the cost of coal per ton delivered and the time load factor in hours per year.

In considering turbo-generators, the cost of one pound of steam per hour at the turbine throttle, which may be called A, equals the cost per ton of coal delivered divided by the product of the evaporation factor and the number of pounds per ton (2000 or 2200). With a given time load factor of B hours per year that this unit will operate, the cost of one pound of steam per year of that many operating hours will be the product or AB. The annual steam charge will therefore equal AB multiplied by the number of pounds of steam used by the turbine per hour.

Evidently the total cost of owning and operating the unit will be the sum of the fixed and the operating charges above stated. Comparison of these total costs, derived from the data supplied by various bidders, presents an eminently fair basis for making an award, provided the mechanical and structural details of the units under consideration are comparable and acceptable.

For comparing turbine-driven centrifugal pumping units, a similar calculation is offered with the additional consideration of the duty factor. While the economic performance or the duty of a pumping engine was originally expressed as work in terms of coal used, it is now commonly expressed as the amount of work in foot-pounds performed per thousand pounds of steam consumed (including or excluding that of the auxiliary machinery) or per million B.t.u. available in the steam. There is little doubt that eventually the B.t.u. basis will

be recognized as the superior one, especially in considering extraction type units, although at present the steam basis still holds its popularity. The earlier definition of duty in terms of coal used has fallen into deserved disuse because of apparent inaccuracy and also because of lack of uniformity in the heat content of various types of fuel.

In passing, complimentary reference should be made to the efficiency of the individual engineering societies' committees in establishing universally-accepted practice for definitions, specifications and test codes. These subjects have not only been treated exhaustively but have been revised from time to time in keeping pace with the development of the arts. There has been no corresponding impetus given by the engineering societies, acting as supreme technical authority, to the evolution and general adoption of evaluation calculations. These have been left to the individual judgment, knowledge and preference of the buyer. This subject, therefore, might well merit authoritative engineering society attention, rather in the form of suggested guides than as rigid, invariable requirements.

Typical Methods of Evaluation That Have Been Used

Several examples of processes of evaluation may be of interest. In June, 1923, the city of Chicago predetermined annual fuel charges as equivalent to specified duty performance. A tabulation states duties at intervals of five or ten million foot pounds per thousand pounds of steam and the corresponding fuel charges. Results between those given were obtained by interpolation.

In Chicago, January, 1924, and in Cleveland, March, 1924, bidders were required to state the steam flow to the condenser in pounds per hour equivalent to specified pumpage rates. A fixed weight or load factor was given to each pumpage rate and the sum representing total steam consumption was capitalized at the prevailing cost per pound of steam, for the life of the unit, flowing to the condenser.

In July, 1925, the city of New York issued specifications containing a different scheme for arriving at a basis of comparison of the bidders' proposals. Fixed charges, taken at 9 per cent of the bid price and capitalized on an annuity basis at 4½ per cent. for 25 yr. were called item B. The excess duty guaranteed by bidders above a fixed minimum was valued at $1500 for each million foot pounds and called C. The proposal showing the lowest value for the difference between B and C was to be considered the lowest bid.

Suggested Method of Comparing Turbine-driven Centrifugal Pumps

Following is a suggested calculation for the comparison of pumping units of this type. Let us assume the following conditions:

Capacity of pumping unit = 15 million gal. per day

Total dynamic head = 650 ft.

Evaporation factor = 8

Cost of coal delivered = $5.00 per ton of 2000 lb.

Time load factor = 5250 hr. per yr.

Duty = 150 million ft. lb. per 1000 lb. steam

Then $$\frac{15{,}000{,}000 \times 8.3 \times 650}{1440 \times 33{,}000} = 1710 \text{ water hp.}$$

Also, 1000 lb. of steam produce 150,000,000 ft. lb., by assumption, hence one pound of steam produces 150,000 ft. lb. and since there are 1,980,000 ft. lb. in one horsepower hour, it will require $\frac{1{,}980{,}000}{150{,}000} = 13.2$ lb. of steam for one horsepower hour.

Total steam required per hour will then be $1710 \times 13.2 = 22{,}572$ lb.

Coal cost of one pound of steam per hour at the throttle is $\frac{\$5.00}{2000 \times 8} = \$0.00032$. For 5250 hr. the cost is $5250 \times 0.00032 = \$1.68$ and the total annual coal cost for steam will be $22{,}572 \times \$1.68 = \$37{,}921$.

The foregoing calculation may be expressed as a fraction, thus:

$$\text{Cost} = \frac{1710 \times 1980 \times \$1.68}{150} = \$37{,}921.$$

The product of the factors of the numerator is a constant K, since the various factors involved are fixed by the purchaser. Therefore, expressing the duty in million foot pounds per thousand pounds of steam, the above expression may be written

$$\text{Cost} = \frac{K}{\text{duty}}.$$

The duty, of course, will vary with the guarantees submitted in the various bids.

Having determined the annual coal cost of steam, as above, the lowest sum of this cost and the fixed charges would then be considered the lowest bid.

These examples deal somewhat differently with the subject. At present few of the existing methods of evaluation are alike. Nevertheless, the desire and intent of buyers and sellers of equipment to evaluate seems to warrant the development of a uniform method. If this brief discussion shall stimulate interest in establishing such a uniform method suitable for recognition and acceptance in the power plant field, it will have served its purpose.

Improved agricultural and business conditions in the North Central States during the last year are reflected in the annual report of Northern States Power Co., for the twelve months ended December 31, 1925, just issued. Gross earnings for the period showed an increase of 9.89 per cent, as compared with the previous year, while net earnings increased 14.26 per cent.

The most important property added to the system during the year was The St. Paul Gas Light Co. Output of electrical energy for the year exceeded 742,601,203 kw-hr. as compared with 689,576,716 in 1924. Gas output increased from 3,585,245,000 cu. ft. in 1924 to 3,703,126,000 in 1925.

In boiler room operation, the CO_2 indicator should be as constant a companion to the fireman as the steam gage.

Experience Alters Condensing Practice

CHANGES IN DESIGN AND OPERATING PRACTICE REPORTED FROM MANY PLANTS DURING THE PAST YEAR*

CONDENSER DESIGN and construction have undergone considerable improvement and because of the widespread interest an endeavor has been made to obtain information concerning the various types and trend of design. Replies to requests for information from member companies were carefully tabulated both with respect to main units and auxiliaries.

Vertical condensers have been employed in one or two new plants and undoubtedly their use will extend under conditions favoring this type of equipment. One member company reports several years' experience with vertical condensers with the water admitted at the bottom. In all new installations of this company the water

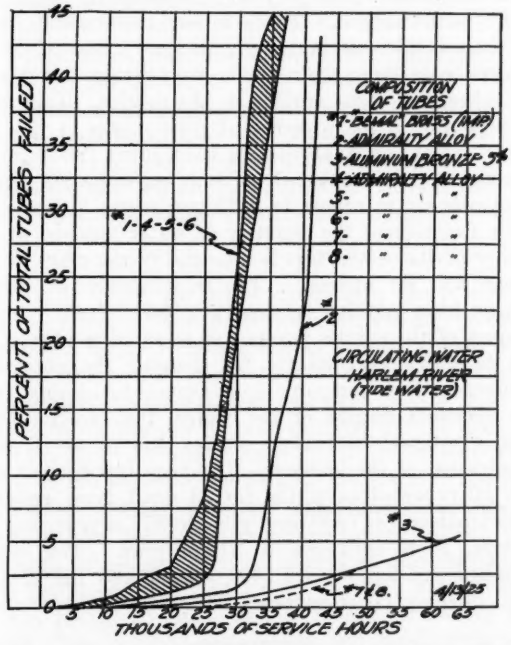


FIG. 1. LIFE OF CONDENSER TUBES AS REPORTED FROM A MAINTENANCE RECORD OF 12 YR.

will be admitted and discharged at the top, as this was found to give much better performance.

No material advantages seem to be gained in the radial flow type condensers by the installation of steam lanes. The installations of the lanes in a condenser at the Gold Street Station did not noticeably improve the performance. At the Hudson Avenue Station, steam lanes have been omitted. Differential tube spacings, however, have been provided, the tubes at the bottom and center being closer together than those at the top and side, affording a constant frictional resistance.

It is felt that there can be no overwhelming advantage for a single-pass design as compared to the two-pass design, assuming that both are equally well worked out. Where a single pass is compared with a two-pass design, both the fixed charges and the operating costs of the circulating pumps should be considered. Where the tunnels are short and circulating water plentiful, a single-pass design will work out well; where the tunnels are long or where circulating water is restricted, the two-pass should show to better advantage than a single-pass condenser.

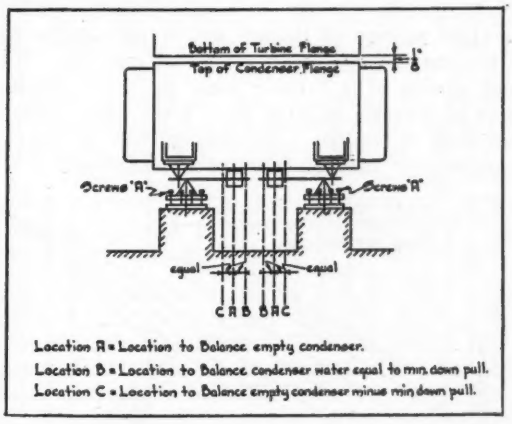

Bottom of Turbine Flange
Top of Condenser Flange
Screws "A"
Screws "A"
equal
equal
C A B B A C
Location A = Location to Balance empty condenser.
Location B = Location to Balance condenser water equal to min. down pull.
Location C = Location to Balance empty condenser minus min. down pull.

FIG. 2. SCHEMATIC DIAGRAM OF CONDENSER EQUIPPED WITH COUNTERWEIGHT SUPPORTS

The majority of installations employ two circulating pumps per condenser, but a smaller number do not employ divided water boxes. Steam jet air ejectors are employed for air extraction in the majority of installations tabulated, while in some instances both steam jet and hydraulic pumps are provided. One plant employs an improved vertical reciprocating dry vacuum pump which possesses many advantages over the older horizontal type.

In the Hudson Avenue installation, external air coolers were rejected because the size of the main condenser could not be reduced and it would have meant an extra piece of apparatus. External air coolers call for longer air passages, thereby producing a greater air friction and a larger possibility of air leakage.

USE OF CONDENSATE BEING ABANDONED FOR COOLERS

Condensate for oil coolers, inter-condensers and air coolers is being abandoned by some, owing to operating difficulties outweighing possible gains. Reliability in operation, rather than economy, is sought. Where cooler water is desirable, the most economical supply is the circulating water. Failure of the hotwell pump or motor will not cause loss of vacuum, nor will the oil from the coolers reach an excessive temperature at light loads when the condensate is insufficient.

There is an increasing tendency to accomplish the deaeration of make-up and boiler feed in the condenser or the hotwell. Eleven of the 45 installations have deaerating hotwells, to which the make-up water is admitted at a temperature above that corresponding to the vacuum in the condenser. Tests made showed completed deaeration but every precaution must be taken

*Abstract of N. E. L. A. Prime Mover's Committee Report, consisting principally of statements by member companies and manufacturers.

to guard against contamination of the condensate with air after it leaves the condenser.

Condenser Leakage Should Be Independent of Size

In comparing condenser performance from the standpoint of either air or circulating water leakage, some engineers feel that the amounts should vary in some proportion to the size of the unit. While the quantity of air admitted with the steam varies with the quantity of steam condensed, it forms but a small percentage of the air to be handled. There is no more excuse for the leakage in a 50,000-sq. ft. condenser exceeding 5 cu. ft. per minute than in a much smaller condenser. The chief sources of leakage are at the flanges where the turbine and condenser are bolted together. Water-sealed glands of a turbine form the most perplexing source of leakage, existing on a great many more turbines than is realized. Air leakage may be kept at a minimum only through constant watchfulness.

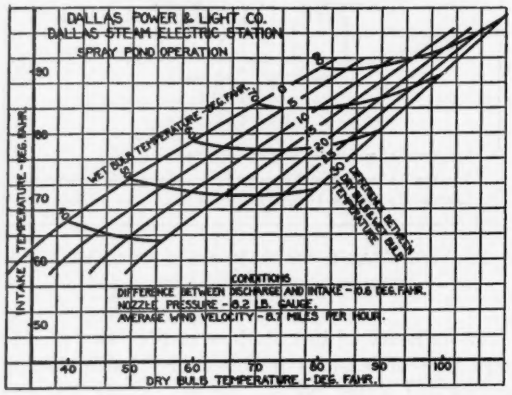

DALLAS POWER & LIGHT CO.
DALLAS STEAM ELECTRIC STATION
SPRAY POND OPERATION
INTAKE TEMPERATURE - DEG. FAHR.
WET BULB TEMPERATURE - DEG. FAHR.
DIFFERENCE BETWEEN DISCHARGE AND INTAKE TEMPERATURE
CONDITIONS
DIFFERENCE BETWEEN DISCHARGE AND INTAKE - 10.6 DEG. FAHR.
NOZZLE PRESSURE - 6.2 LB. GAUGE.
AVERAGE WIND VELOCITY - 8.7 MILES PER HOUR.
DRY BULB TEMPERATURE - DEG. FAHR.

FIG. 3. SHOWING THE EFFECT OF WET AND DRY BULB TEMPERATURES ON SPRAY POND OPERATION

Wire brushes, although much more efficient than rubber plugs, are prohibited with the Hudson Avenue condensers by the length of time required. Rubber plugs are used. Each night one-quarter of a condenser per group of two units is cleaned. The same one-quarter is, therefore, cleaned every eight days. Blowing rubber plugs is the only system which will permit this schedule. The type of plug undercut near the ends has not proved as satisfactory as a solid rubber plug.

Long Record Shows Life of Various Tube Metals

Condenser tubes and tube failures received considerable attention, one member reporting the additional cost of No. 16 gage tubes being amply repaid by more satisfactory service and longer life than the standard No. 18 gage. Three different kinds of alloy were initially used in the tubes of the first three condensers at the Sherman Creek Station. Unit No. 1 was equipped with Bemal, the second with Admiralty alloy and the third with 5 per cent aluminum bronze tubes. All subsequent additions employed Admiralty alloy tubing. This plant was placed in operation in the latter part of 1913 and, since that date, three condensers have been retubed, the fourth requires tubing, and from present condition, the fifth unit will require retubing this year. The chart, Fig. 1, indicates the service hours life for the various tubes which were installed.

To provide a flexible support to compensate for the expansion and contraction of the condenser, due to temperature changes, a counterweighed lever support for condensers has been developed for the Richmond Station of the Philadelphia Electric Co. The method is shown in Fig. 2. After the counterweights are set and the condenser filled with water, the turbine will be carrying the weight of the circulating water plus the minimum downward pull. Any change in distance between the turbine shaft and condenser feet, due to changes in temperature, will not affect this apportionment, which is contrary to the effect produced by the use of springs. The loading of the supports will not change and the loading on the turbine will vary only when the quantity of water is changed.

Cooling Ponds Still Necessary in Some Localities

Of the isolated plants still operating and cooling their circulating water, by far the majority favor the spray pond method. These report maintenance costs on their condensers as negligible; only one of which reports scale from their ponds giving them trouble in the tubes and slight trouble in the nozzles. This trouble was due to the presence of precipitates in the raw water, which, on analysis and subsequent treatment of the make-up, disappeared. Pump maintenance ranges from nothing to report to $125 per year. It is clearly not a function of the quantity of water pumped or the nature of the water, but is inherent in the make of the pump and its upkeep. The maintenance of piping ranges from nothing to report to $30 a year. Maintenance of the nozzles is reported as ranging from nothing to $65 a year mostly for cleaning the nozzles of sediment. One company only reported clogging from the chemical nature of the water, the expense being mostly renewal of broken nozzles due to too free an application of the hammer. The very few cooling towers, all reported as of the forced draft type, range in maintenance cost from negligible to $75 a year, and the pumps, from negligible to $10 a year. The largest capacity did not exceed 1600 g.p.m., and the greatest size, 1400 sq. ft. of surface.

Haulage Problem Solved by Motors

At the Birmingham plant of the Southern Clay Manufacturing Co., it was necessary to provide some form of transportation by alternating current for transferring loaded larry cars from the drying ovens to the kilns. The problem was solved by designing a transfer car to carry one larry car weighing approximately 2900 lb. loaded. Power is supplied from three overhead trolleys connected to the 220-v., 3-phase source. The driving motor is a General Electric, 5-hp., 900-r.p.m., 3-phase, 60-cycle, 220-v. machine, and a duplicate motor is mounted on the car driving a winch used to pull the larry cars on and off the transfer platform.

Control is provided by a drum controller and a resistor, both of General Electric make. The control regulates the driving motor while moving the car. It is then switched over to the winch motor which pulls a loaded larry on the transfer platform, and then it is switched back to the driving motor. A satisfactory and economical control for the transfer car is thus provided.

Boiler Feed Water Should Be Measured

SUITABLE METERS SUPPLY INFORMATION FOR ENTIRE ORGANIZATION AND RAISE MORALE OF MEN

NEGLECTING, for the moment, large power plants and central stations where close supervision of operation is a necessity, to review the progress of smaller industrial plants, it is evident that the barriers which once isolated the power plant from the remainder of the organization are fast disappearing.

Not so many years ago, the chief engineer and his plant were considered too technical to allow supervision. They existed, a small despotism tolerated by the remainder of the organization, as a necessary evil. The war, with its acute fuel problems, followed by a period of severe competition demanding lower production costs, brought the cost accountant into the engineer's domain.

Far-sighted engineers grasped the opportunity of bettering their plants, of being recognized as an important part of the organization and incorporated such data as departmental duties. Those less far-sighted objected to what they considered interference and executives were not long in learning that a little supervision shows up a poor employe and improves a good one.

BOILER ROOM IS A PRODUCTION UNIT

In any plant the boiler room is a manufacturing unit engaged in the production of steam. Whether this steam be used for generating power, process work, or sold, some unit of production must be established to measure the output and correlate results with the remainder of the plant. The greatest ally of efficiency is knowledge. In the boiler room the boiler feed water meter is the keystone, flanked by coal and CO_2 meters.

Taken by itself, the feed water meter supplies important data for the entire organization. Steam used per unit of output may be calculated for comparison with past records or with similar plants. Furthermore, over a period of time total costs can be closely estimated from accounting records and used with total evaporation figures to give a unit steam cost.

Charts from recording meters show the periods during which peak loads can be expected while the quantity of water flowing at any time can be checked against the number of boilers in operation, thus permitting the engineer in charge to determine whether the right number of units are being kept under fire to obtain the most economical results. Often it is possible to improve the efficiency of the plant by changing the time for certain operations to avoid peaks in the load.

Meter records will not, of course, be a true indication of the instantaneous steam load because of the lag occasioned by feeding the boiler. It is fully realized by most operating engineers that irregular feeding of water to boilers not only kills the steam but also introduces unnecessary strains in the boiler structure due to sudden temperature changes occasioned by the influx of large amounts of comparatively cold water. When automatic feed water regulators are used for this service individual feed water meters furnish a continuous dependable check on the performance of these devices inasmuch as any irregularity in their performance shows up immediately on the feed water chart.

The greatest value of the individual meter, however, is the information it supplies regarding the distribution of load between different boilers. Every boiler has a point of maximum efficiency and, although a battery may be averaging the correct value, it is possible for individual units to be far from the average, with one or two boilers carrying the bulk of the load and others loafing.

CENTRAL STATIONS MAKE EXTENSIVE USE OF METERS

In the larger plants, such as central stations, provision is practically always made to measure the steam output from the individual boilers as well as to measure the total feed water to all the boilers. The feed water meter is depended upon, together with the steam flow meters, to furnish data concerning the losses due to blow down and leakage between the feed water meter and the steam header. The comparison of the readings obtained from the feed water meter with those obtained from the individual steam flow meters gives this information. In addition to the provision for the measurement of total feed water supplied to the boilers, the large central stations often provide an orifice in the individual feed water lines and either use a portable fluid meter or a meter permanently installed for the purpose of checking up on the individual boiler performance. This feature is used particularly in test work when a close check on the quantity of water fed as well as the steam generated is required.

Used with other measurements—coal burned, steam flow, CO_2, various pressures and temperatures—complete cost accounting, engineering and executive information is available. It is not the amount or quality of coal used, but the relation of this coal to the final quantity of useful steam produced, which represents the ultimate efficiency of the plant. To determine this ratio accurately, an equally accurate measurement of coal and water is the only practical test, as it shows results obtained from a given coal under actual plant conditions. The suitability of various fuels under actual plant conditions cannot be shown by a mere calorimetric test.

Tests under actual or ideal conditions can be made to set a standard for everyday operation. Boiler feed records will then show to what extent this ideal result is being attained while the influence on the morale of the men is tremendous. Faulty results can be detected and good ones rewarded. Falling off in efficiency due to defective baffling, air leaks and other causes can be detected while tests to determine the efficiency of soot blowing, scale removal, furnace repairs, various methods of firing, and different thickness of fuel bed can readily be made.

Records of feed water temperature on the same chart with the rate of flow furnish complete information regarding both quantity and the condition of the water, as well as information regarding the size, condition and operation of the feed water heater. If desired, feed water pressure and steam pressure, or both, can be recorded on the same chart with feed water temperature and rate of flow. If all of these records are included on the same chart, the rate of flow of water, its condition and the differential between the feed water pressure and steam pressure are apparent at a glance. When economizers are used, recorders can be used to give records of flue gas temperature and feed water temperature entering and leaving the economizer.

Coal Carbonization on Large Scale at Milwaukee

Two-Stage System Is Installed with Capacity of 210 T. of Raw Coal a Day to Supply Pulverized Coke for Boiler Fuel

IN THE McEwen-Runge system for low-temperature distillation of coal, which was first conceived and studied by Samuel McEwen of International Combustion, Ltd., London, and brought to its present state by Dr. Walter Runge of International Combustion Engineering Corp., the effort has been to produce a fuel suitable for large steam-making plants, by carbonizing pulverized coal to a semi-coke which can be burned in a pulverized coal furnace with high combustion efficiency.

Early experiments were with a horizontal travel of the coal particles but operating difficulties were encountered which turned attention to a vertical travel system, the coal particles falling through a rising current of gas, thus retarding the settling of the coal and giving a longer period for carbonization. Facilities not being available in London and pulverized coal not easily had, work was transferred to Milwaukee and experimental development undertaken with the co-operation of John Anderson, vice president of the Milwaukee Electric Ry. and Light Co., at its Lakeside plant, this work being in charge of Dr. Runge.

Development of Two-Stage Method

Problems to be solved were: The time required to carbonize coal when in a finely divided state as this governed the height of the column; whether coking coal would build up on the sides of the retort, thus causing stoppage; whether gas velocity could be so controlled as to secure carbonization and settling of coke particles without carrying dust through the gas off-take pipes.

As there were no precedents, the retort was built of such size and height as would place it in the semi-commercial stage, within the limitations of space available. It was simple, to avoid excessive cost but of continuous type to approximate probable conditions in a commercial plant. Total height of 48 ft. was used, a 12-in. pipe, heavily covered with asbestos, being flared to 30-in. diameter at the top. This gave a carbonizing zone of 30 ft., hot gases being introduced at the bottom from an external oil combustion chamber and coal at the top through an inlet pipe extending down some 3 ft. Coke was removed from a receiving chamber below the gas inlet through double sliding gates which avoided admission of air when coke was taken out. Gases were taken off at the top. The use of a fan, installed to disperse the pulverized coal and prevent channelling, was found unnecessary and discontinued.

In experiments, almost continuous from March to November, 1924, Youghiogheny coal was used with 34.6 per cent volatile, 57.64 per cent fixed carbon, 7.76 per cent ash and heat value of 13,942 B.t.u. per pound. It was dried to 1 to 1.5 per cent moisture, then pulverized so that 59 per cent passed a 200-mesh screen, 85 per cent a 100-mesh screen, 99 per cent cent a 50-mesh and 100 per cent a 40-mesh.

Average carbonization temperature was to be determined, for which purpose five pyrometers were installed in the retort. The lowest section was, of course,

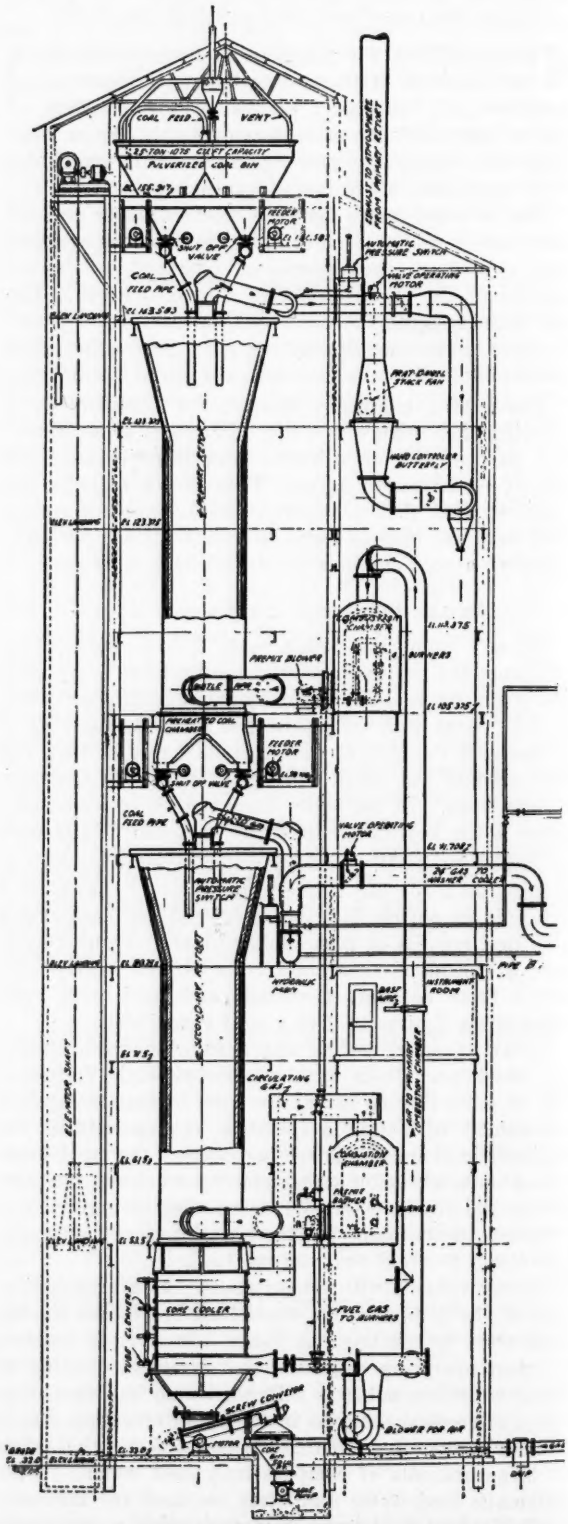


FIG. 1. COKING QUALITIES ARE REMOVED IN THE UPPER RETORT AND CARBONIZATION TAKES PLACE IN THE LOWER

hotter than the upper ones, but it was found that to devolatilize the coal to 10 to 12 per cent volatile matter in the residue, the highest temperature had to be 1500 deg. F., which gave about 1050 deg. F. average through the retort. For 900 deg. average temperature, the volatile in residue was 17 per cent and for 750 deg., 21.8 per cent. These are gas temperatures and readings on the coke as it left the retort indicated that it was 100 to 150 deg. cooler than the gas at the bottom, a difference probably maintained throughout.

Carbonization is governed by temperature and time, so that the volatile in residue would undoubtedly be different at the temperatures given if longer or shorter time was taken by the coal in passing through the retort. In this case, the average time was 35 sec. although it varied considerably in individual tests. Carbonizing was progressive as shown by samples of coal withdrawn from different zones. If, as is likely, velocity of the descending coal was constant, conditions were as shown below:

Temp.	From Coal Inlet		Vol. Matter
deg. F.	Time, sec.	Dist., ft.	Per Cent
560	1	1	32.1
765	12	10	26.7
1265	22	19	15.5
1495	35	30	8.5

It was found that, in continuous operation with coking coal, there was partial stoppage due to building up on the sides of the retort, as had been anticipated. This was sometimes as thick as 4 in. and broke away in lumps which defeated the object of the process as well as hindering operation. It, therefore, became necessary to find a way to destroy the coking quality of the coal.

Sinnatt had shown that by heating Lancashire coal in a 420-deg. atmosphere of nitrogen for 18 sec. coking qualities were lost, but nitrogen was not practicable, so hot air was tried, the coal falling from the top through a current of rising air introduced at the bottom. Results showed that up to 375 deg. F. there was no destruction of coking; at 467 and 600 deg. there was partial destruction; at 647 deg. and above, the residue was non-coking. By operating at 650 deg., which removed only ½ to 1½ per cent of volatile, it was possible to accumulate a quantity of non-coking coal and dust indications in the gases were present for only 3 to 4 min. after starting operation. An unlooked for condition was that the finer particles of the semi-coke had more volatile remaining than the coarser particles, because the larger particles were due to swelling during partial carbonization. The semi-coke was sandy, granular, easily broken, so that, though not as fine as pulverized coal, it will break up when handled by conveying mechanisms. It passed 6.8 per cent through 200-mesh, 21.6 per cent through 100-mesh, 50.4 per cent through 50-mesh, 69.6 per cent through 40-mesh, 96.8 per cent through 30-mesh and 100 per cent through 10-mesh screens. The larger particles are, in many instances at any rate, hollow, with a thin porous shell

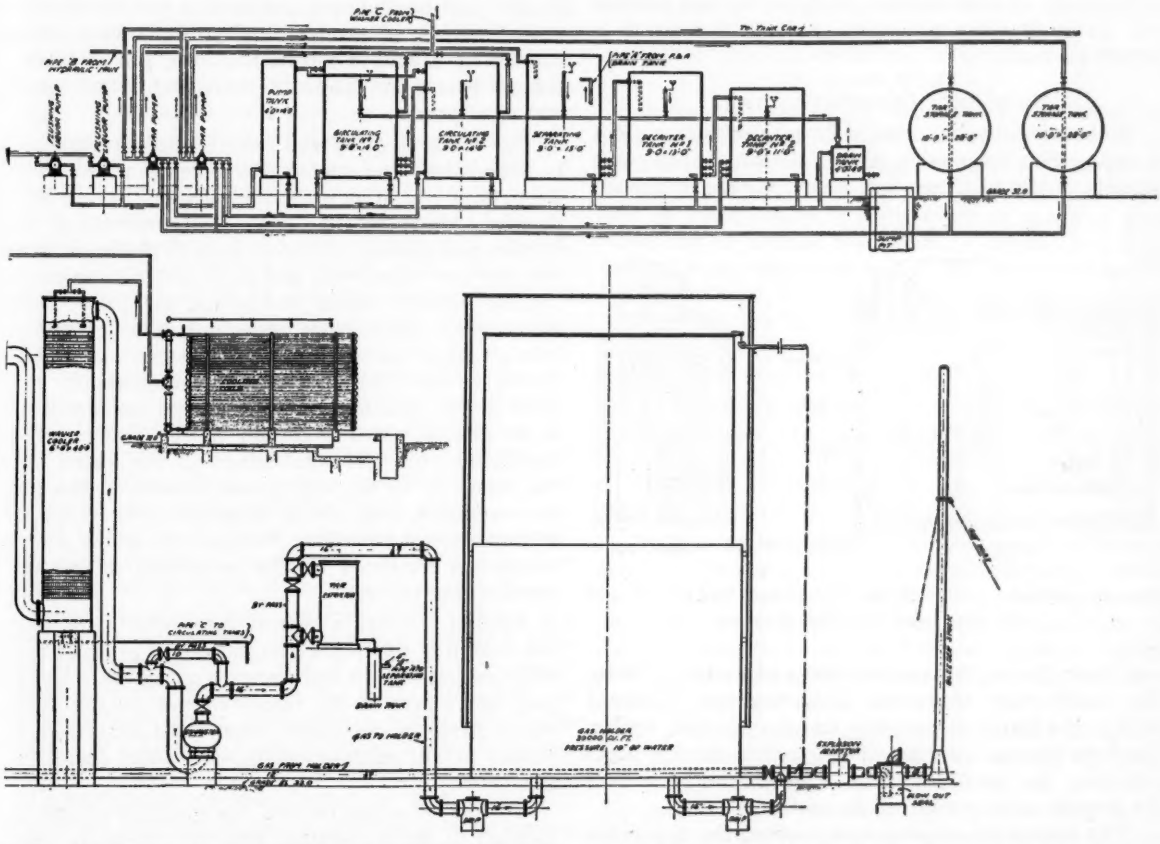


FIG. 2. GAS IS TREATED TO REMOVE TAR WHICH IS WASHED AND STORED, THE GAS THEN SCRUBBED AND SENT TO A HOLDER

which, it is thought will have a higher rate of combustion than coal.

In some interesting experiments it was found that, after bringing the retort to temperature, the external supply of hot gas could be shut off and a current of air substituted, the heating and carbonization being kept up indefinitely by combustion of part of the coal. Estimate shows that burning 72 lb. of coal would give heat to carbonize a ton, thus consuming 3.5 per cent of the fuel and giving a gas similar to producer gas, varying in heat content, about 15,000 cu. ft. per t. of coal treated.

Running the treated coal through the retort a second time, it was possible to operate continuously without stoppage and producing a fully carbonized product with 10 to 12 per cent volatile, suitable for use as a pulverized fuel.

Milwaukee Commercial Plant

Embodying the data learned from these tests, a plant is now nearing completion at the Lakeside station, with capacity of 210 t. of raw coal a day, to take pulverized

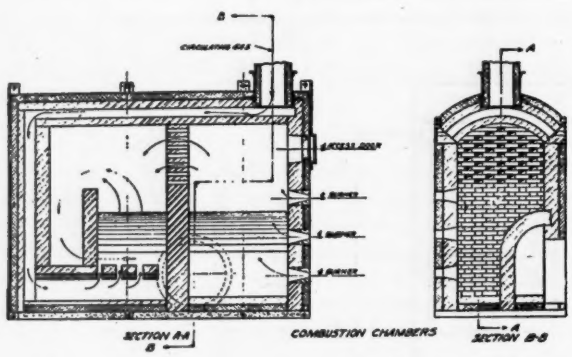


FIG. 3. SPECIAL COMBUSTION CHAMBERS HEAT THE AIR AND GAS USED IN THE RETORTS

coal from the station storage bins and carbonize it by the double-stage treatment, delivering the powdered coke to the boiler storage bins and the gas to a holder. Tar from the gas is condensed and put into storage tanks for sale. In the illustrations, Figs. 1 and 2, is seen the general arrangement of the system.

The retorts are alike in construction, the upper one serving for the destruction of coking qualities and the lower for carbonization, hence heated air is supplied to the upper and hot gas to the lower. The structure is 150 ft. high, each retort being 6 ft. 9 in. diam. by 38 ft. high. They are steel shells, provided with slip joints and lined with Sil-O-Cel brick. From coal inlet to the bustle pipes, which supply air or gas, the carbonizing zone is 30 ft. Fuel is fed by four star feeders per retort and gas removed by two off-take pipes at the top.

At the top is a 25-t. feed hopper for supplying coal to the upper retort and two 50-t. bins, not shown, are provided for storing pulverized coal. A small hopper between primary and secondary retorts acts as supply bin for the lower one and coke is collected at the bottom in a cast-iron cooler having tubes and baffles through and over which gas coming to the furnace to be burned is passed seven times, preheating the gas considerably and cooling the coke below the point of spontaneous combustion. Soot blowers are provided to keep the tube surfaces clean but it is expected that their use will be infrequent.

Coke is taken from the bottom of the cooler by an inclined screen to a transport pump which conveys it directly to the storage bins of the boiler plant. From the primary retort, gases are drawn by an exhaust fan and wasted to atmosphere. Temperatures are low so that no valuable products are carried by these gases which are mostly carbon dioxide, nitrogen and water vapor.

Because of higher temperatures employed, gases from the secondary retort are rich in valuable gaseous and liquid products, hence are removed by an exhauster and treated as is common in gas practice, precipitating most of the tar in a hydraulic main and the balance in a washer scrubber. Clean gas is taken to the gas holder for use in the secondary retort heating, and city supply.

Gas for preheating and carbonizing is controlled as to temperature and quantity by furnaces shown in Fig. 3. These are of brick with steel shell and having Maxon Premix burners in the front. Hot products of combustion pass through a checker work to the second chamber and are mixed with gas to be used in the retorts; for the primary retort this is air, for the secondary retort, gas. The mixture passes over a bridge wall and into a tunnel, seen at the right in section BB, Fig. 3, thence to the bustle pipe which supplies the retort through two nozzles which discharge tangentially so as to give a whirling motion to the rising gas and descending fuel. The gas mixed in the second chamber comes in at the top, passes between arches above the combustion and mixing chambers, down at the back and up through the floor. Temperature of the outgoing mixture is regulated by the proportion of gas taken through the burners.

Control is from a central room where are located two recording pyrometers, an indicating pyrometer, CO_2 recorder, gas meters and pressure gages. Gas and coal feed are regulated by remote-control motors from a switch panel in the control room and inter-station telephones permit communication with plant operators at any time.

By the two-stage method, the quantity of gas to be handled in the by-product recovery system is reduced and quality improved, since heating of the coal from 70 deg. up to 500 deg. F. is done in the first stage, from which the worthless gas is wasted. Where process gas is not available, the retorts can be brought to working temperature by oil burners and the partial internal combustion method used for carbonization until gas is generated sufficient to operate the retorts. Various combinations of operation can be used with the system according to the solid and gaseous fuels desired as products.

Advantages of the system are stated by Dr. Runge, in the article in Coal from which these data are taken, as: Simplicity; treatment of coking or non-coking coals with small quantity of gas to be handled; production of fine coke for dust firing; low fuel consumption; gas of various standards may be made; no moving parts in the heat zones; recovery of heat from the coke; central control; low labor cost.

Diesel Engines for Direct Drive

CONNECTED TO PUMPS AND COMPRESSORS THEY MAKE A RELIABLE, ECONOMICAL COMBINATION. BY F. I. KEMP*

COMPARATIVELY little consideration has been given the oil engine and its resulting economy when directly connected to pumps or air compressors although it is one of the basic principles of engineering that the use of power directly applied produces best economy.

We will take up first the problem of pumping water and deal with this subject, so far as possible, making comparisons with electric drive largely because there is not sufficient time available in which thoroughly to study steam plants.

Small Diesel engines require approximately 0.5 lb. per br.hp-hr., so that the resultant duty with a pump having 83½ per cent efficiency will be 178,500,000 ft-lb. per million B.t.u. Compare this with a steam plant using a crank and flywheel pumping engine of the same size where you will find the duty to be approximately 85,000,000 ft-lb. per million B.t.u. The highest duty yet obtained by a steam pumping engine in water works service is about 172,000,000 ft-lb. per million B.t.u., or on a steam turbine-driven centrifugal unit approximately 145,000,000 ft-lb. per million B.t.u. This, however, can be raised up to somewhere near 160,000,000 ft-lb. per million B.t.u., by higher steam pressure and superheat. It is, therefore, apparent that from a heat unit viewpoint the smallest Diesel engine is more economical than the most highly developed steam equipment. Larger sizes of Diesel engines with correspondingly larger pumps can reach a maximum of 230,000,000 ft-lb. per million B.t.u. or about one-third better than the best steam pumping unit ever built.

Let us assume, in order to make a start, the conditions which obtain in a certain city in the Kansas City district, a definite problem and not an imaginary one.

Diesel engines driving vertical triplex pumps can supply water at the rate of 700 g.p.m. against a total head of 307 ft. for a total cost of 3.02 ct. per thousand gallons pumped. To supply water at the same cost with a motor-driven triplex pump power would have to be available at 0.811 ct. per kw-hr., or, with a motor-driven centrifugal pump at 1.69 ct. per kw-hr.

From this we can safely conclude that, unless the installation in question was so situated as to be almost in the back yard of a large efficient central power station, the oil engine-driven pump would prove to be the most profitable investment.

LARGE UNITS GREATLY REDUCE COSTS

Let us now proceed to a larger installation—one for a city where the yearly average daily consumption would be 15 m.g.d. against a total pressure of 100 lb. and the maximum daily consumption 20 m.g.d. This would correspond to a city of about 100,000 population. There are several selections of equipment which could be made but, for our purpose, we will choose three units, each with a capacity of 10 m.g.d. or 6950 g.p.m. each, so that there would be one reserve unit during the period of maximum water consumption.

On the basis of fixed charges equaling 13 per cent on the equipment and 7 per cent on the building, water could be delivered by a Diesel driven centrifugal unit for 1.128 ct. per thousand gallons pumped. In order for a motor-driven unit to equal this, power would have to be purchased for 0.69 ct. per kw-hr.

The foregoing figures have given you something of the costs of pumping water with Diesel engines and it obviously is not intended that they will cover all cases as each pumping problem must be considered as a more or less special case. We believe, however, that we are quite safe in making the statement that if the oil engine were more seriously investigated by engineers in connection with pumping problems, in the light of present day oil engine developments, there would be considerably more installations made.

ENGINES DIRECT-CONNECTED TO COMPRESSORS SERVE LARGE MINES

Operating costs of air compressors with Diesel engines is determined in exactly the same manner as has been used in water pumping costs. The analysis following is one which was made in connection with a central air plant supplying air to a certain group of mines where the air demand was carefully checked and it was decided to use three compressors, each delivering approximately 2000 cu. ft. per min. Two-stage duplex 26½ by 16 by 18-in. machines are arranged for direct-connection to a 400-hp. oil engine, the actual horsepower required when compressing to 100 lb. being 391.

Total installation costs would be approximately $145,000.00 and the total yearly cost based on 5-cent fuel, 9 hr. per day, and 300 days per year, is $32,240.00. If we assume a 2/3 average load, the total cost per thousand cu. ft. will be 4.23 ct.

Comparing this with a synchronous motor-driven installation, having a first cost of approximately $60,000.00, we find that it is necessary for power to be purchased for 0.863 ct. per kw-hr. to equal the oil engine on the full load condition. On the 2/3 load condition, current would have to be purchased for 1.118 ct. per kw-hr. to produce equal costs.

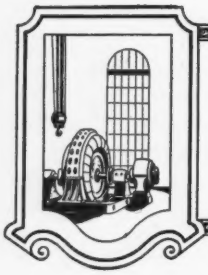
We have records of an installation which delivers air at a cost per 1000 cu. ft. of 0.467 ct. for fuel and lubricants, based on a fuel cost of $1.00 per bbl., or 2.38 ct. per gallon. It is, therefore, quite evident that the oil engine is an economical prime mover, whether the work be pumping air or water, and is also easily applied to any type of equipment.

PREJUDICE AGAINST DIESELS USUALLY GROUNDLESS

Considerable prejudice exists in the minds of some engineers against any oil engine and when this is traced, it is found that it is usually based on hearsay or on experiences with engines of an old type. Diesel engine practice has advanced as rapidly as that of any other type of equipment, steam turbines for example, and nobody with good judgment would state that turbines of today are no better than they were 10 yr. ago.

The reliability of Diesel engines, when applied to work such as I have described, is dependent largely on one factor and that is, strange to say, not the engine, but the operator. Practically any Diesel engine on the market today will give satisfactory service if properly installed and intelligently handled.

*Manager Kansas City office, Worthington Pump & Machinery Corporation. Abstract of paper presented before Oil and Gas Power National Conference, April 19-24, 1926.

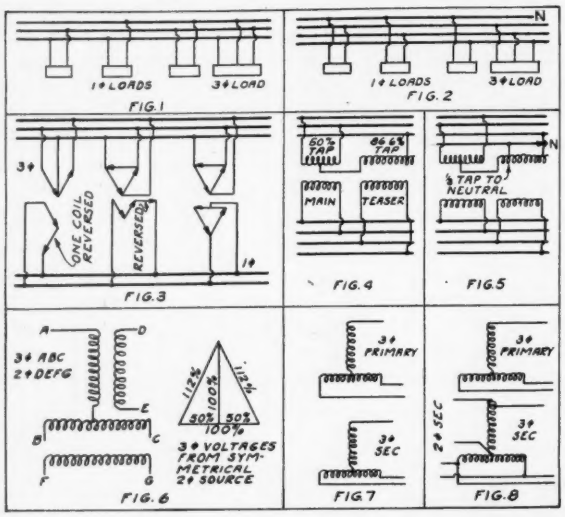


ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Transformer Connections---VI*

CONSIDERATION OF PHASE TRANSFORMATION WITH STATIC AND ROTARY TRANSFORMERS. BY V. E. JOHNSON

DOMESTIC installations of power equipment, for the most part, use the three-phase system, but a considerable number of two-phase plants still exist. It is therefore desirable to provide means for changing



FIGS. 1 TO 8. THESE STATIC TRANSFORMER CONNECTIONS HAVE BEEN DEVISED FOR CONVERTING THREE PHASE PRIMARIES TO SINGLE, TWO OR THREE PHASE SECONDARIES

from one to the other by means of suitable transformations. Single-phase generators are practically obsolete for ordinary power use, although there are a number of special applications where single-phase power is widely used. Six-phase rotary converters are common and have almost entirely supplanted the three-phase apparatus. It is therefore evident that phase transformation is an important part of the work that must be accomplished by means of static transformers.

THREE PHASE TO SINGLE PHASE

Main feeders going out from the power houses and substations are generally three phase; single-phase lighting loads are supplied by tapping off from any pair of wires, as shown in Fig. 1 and Fig. 2 which show schematically the three-wire and four-wire systems of distribution. While the ultimate loads are small as compared to the station capacity, a careful balancing of the taps taken from the three phases will result in a nearly symmetrical polyphase demand on the system. On the other hand, with large and varying single-phase loads this is not true and it would be desirable to provide some means whereby they could be supplied without unbalancing the three-phase feeder.

Many attempts have been made to do this but without success, the stumbling block being that polyphase systems generate a continuous flow of power, while single-phase loads are pulsating. It is obviously impossible to transform from a continuous to a pulsating power flow without providing some reservoir of energy to absorb the variations. Thus a three phase-single phase motor generator set would have flywheel effect which would tend to compensate for the difference in the fundamental characteristics.

Static transformers have no such storage capacity or flywheel effect, so that a single phase-polyphase transformation will not be able to produce balanced loads on the three-phase system. There is really no advantage obtained by using any of the special schemes that have been devised; tapping from one pair of wires gives as good result as any.

Figure 3 shows some of the arrangements that have been devised, and which are being used with varying degrees of success. None of them cure the fundamental difficulty.

TWO-PHASE TO THREE-PHASE TRANSFORMATION

In this case the flow of power is uniform, so that transformation is simply a matter of changing the phase relations. It is generally accomplished by some form of T connection. The most accurate scheme is that known as the "Scott" connection as shown in Fig. 4.

The transformers are designated as the "main" and the "teaser," the latter having a 86.6 per cent tap and the former a 50 per cent tap connected. The two units are usually alike, both having 50 per cent and 86.6 per cent taps, so as to be interchangeable. The three-phase voltages are balanced, but there is some phase displacement between voltage and current. Due to this displacement and to the fact that 14.4 per cent of the teaser turns are idle, the capacity of such a bank is somewhat reduced.

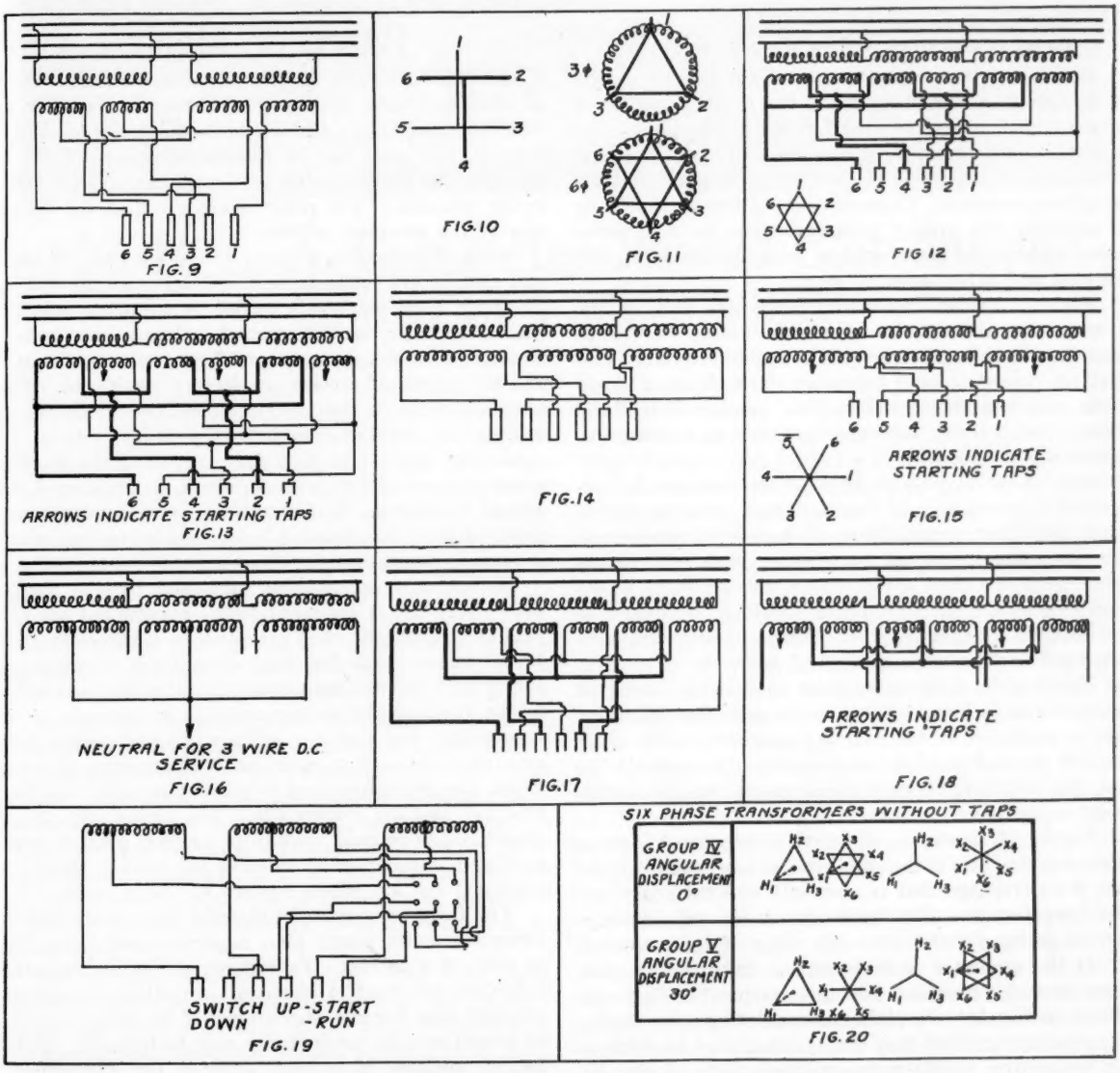
Figure 5 shows a Scott transformation with the three-phase side arranged for four-wire operation. The neutral tap is brought out on the teaser ⅓ of the way up from the interconnection between the main and the teaser.

*Preceding articles of this series appeared in the following issues of Power Plant Engineering: Sept. 15, 1925; Nov. 1, 1925; Dec. 1, 1925; Febr. 15, 1926, and April 15, 1926.

It is by no means necessary to use transformers having 86.6 per cent taps, for very satisfactory commercial operation is obtained by using the whole winding on the teaser. This connection is shown in Fig. 6. It should be noted that this is not an entirely symmetrical transformation, as the phase relations and voltages can not be simultaneously correct on both sides. If power is being transformed from two phase to three phase, the voltage triangle on the latter side will not be equilateral, but will instead be isosceles, with an altitude greater than the base, as shown in Fig. 6. The angular relations are not symmetrical, nor are the voltages exactly equal.

If power is being transformed from three phase to two phase, the latter voltages are at the correct displacement of 90 deg. from each other, but they will not be equal. The unsymmetrical connection is therefore not suitable for use in paralleling three-phase to two-phase alternators, where true voltage and phase relations must be maintained, but for driving motors and similar applications the scheme is entirely feasible.

The Scott connection or the unsymmetrical T connection may also be used for straight three-phase transformation, or they may be used to supply simultaneous three-phase and two-phase loads from the same bank. Figure 7 shows the arrangement for supplying three-phase loads, while Fig. 8 shows the leads brought out for two different systems as indicated.



FIGS. 9 TO 20. ROTARY TRANSFORMER CONNECTIONS

Two-phase to Six-phase Transformation

Use of six-phase current is confined practically entirely to synchronous converters, but as these are common, the connections involved are of considerable importance. The two phase-six phase method of transformation consists essentially of two transformers so connected as to produce a phase displacement of 120 deg. in two different combinations, and then joining these at 180 deg. producing a symmetrical six-phase voltage.

Figure 9 shows the actual connections used, while Fig. 10 gives the voltage diagram. It will be seen that the latter consists of two T diagrams connected in opposition. The transformers are not able to develop their full individual ratings because of the phase relations between voltage and current, so that the total bank capacity must be 15 per cent in excess of the rotary rating.

Three-phase to Six-phase Transformation

Because of the preponderance of three-phase generating and transmission systems, the great majority of rotary transformers are used for this application. Figure 11 shows schematically how the continuous winding of a rotary converter is tapped for three-phase and for six-phase operation. There are several common methods of securing the proper phase relations from a three-phase system, the most common being double delta, diametrical and interconnected star.

Figure 12 shows the actual connection and voltage diagram for the double delta connection. It will be seen that each transformer has a double secondary and that the three left-hand halves are formed into a closed delta, the right-hand halves into another delta, and finally that both of these are connected at a phase displacement of 180 deg.

It is usual to provide taps in the primary for adjusting the voltage. If the converter is to be started from the direct current side, no taps are necessary on the six-phase side of the transformer bank. If, on the other hand, starting is to be from the alternating current side of the machine, reduced voltage taps must be brought out for that purpose. Figure 13 shows the bank arranged for the latter method of operation.

The double delta connection with delta connected primaries as in Fig. 12 has the advantage that operation can be continued if one unit is damaged. On the other hand it can not be used for three-wire d.c. service without the addition of auto-transformers, as no neutral point is available.

Figure 14 shows the schematic connection known as diametrical. This is the simplest and most common, and has the advantage that it uses only one secondary coil per transformer. The leads are in no way interconnected, going direct to the slip rings of the converter.

If the converter is to be started from the a.c. side, taps must be provided for this purpose. These are shown in Fig. 15. On plain non-regulating pole rotaries, the neutral for three-wire d.c. systems, may be obtained by connecting together the middle points of the diametrical windings as shown in Fig. 16, but this neutral connection must be opened during starting.

Figure 17 shows the interconnected star arrangement. If starting taps are required these are brought out as in Fig. 18.

Starting Taps on Converter Transformers

These may be provided on any of the general methods of connection, as already outlined. Figure 19 shows a starting switch with the tap and converter leads brought to it.

This condition is seldom met, but the same general principles which govern three-phase banks must be applied. The phase rotation must be correct, and the phase displacement between primary and secondary must be the same. The Electric Power Club rules express this in a simple and clear manner by means of a diagram, such as that in Fig. 20. Transformers from one group can not be connected with a bank falling in another.

Bonus for Salaried Workers Based on Merit

FOR REWARDING salaried employes, a rather novel plan has been developed by one manufacturer of electrical supplies. Unlike most supplemental bonus systems, this plan has no clearly defined rules but is based on the general merit of the worker and his value to the company. The rewards are given at the discretion of the executive officers.

From the earnings, a reserve fund has been set aside and awards are made from this fund. At the end of the year, each employe's record is surveyed and the character of his service studied. General merit, constructive attitude, the number of suggestions submitted and the length of service are factors considered. This company believes that length of service alone is not sufficient to warrant granting an award.

At the end of the first year, provided the salaried employe's record has been approved, he receives 1 per cent of his salary. This percentage increases 1 per cent yearly until a maximum of 5 per cent is reached, where it remains constant.

Constructive suggestions submitted by the worker not only influence his merit bonus reward but are also paid for separately when accepted, on a rather unusual basis. The rewards for these suggestions are made annually and the amounts granted are graded according to the rank of the worker and the importance of the suggestion. For instance, when a superintendent, foreman and ordinary worker make suggestions of equal merit, the superintendent would receive $10, the foreman $15 and the worker $25. The higher officials are considered to be paid already to produce greater economies and developments, whereas the worker should be rewarded for his efforts beyond his daily work.

The factor of personal judgment that enters into the foregoing merit bonus plan requires careful handling to make it a success. Favoritism, prejudice and other injustices are wont to creep in. An otherwise valuable employe may become discouraged if he fails to receive an award and his productivity may be lessened. Unless logical methods have been adopted for developing a spirit of close co-operation and harmony in the plant, the bonus scheme will be under a serious handicap.

CONSIDERABLE VARIATION exists in the interpretation of the expression, "free air" as applied to compressed air practice. One of the most common mistakes is to assume that free air refers to air under standard conditions, 14.7 lb. per sq. in. and 60 deg. F. This is true only under certain conditions, such as at sea level on a day with normal atmospheric pressure and a temperature of 60 deg. The true interpretation of free air is air under normal atmospheric conditions of the place under discussion and is subject to considerable variation, because of altitude, barometric and temperature differences of various localities.

N. E. L. A. Completes Record Convention

FORTY-NINTH ANNUAL GATHERING REFLECTS THE ENORMOUS ADVANCE MADE IN THE ELECTRICAL INDUSTRY

PUBLIC RELATIONS was the important item which, it would seem, all but dominated the 49th Annual Convention of the National Electric Light Association which was held on the Million Dollar Pier at Atlantic City, May 17 to 21. This does not imply that other matters were in any way neglected but that nearly all of the activities of the association were considered from the standpoint of public relations as much as possible, for it was recognized that the continued success of the association is largely dependent upon the policies pursued in the matter of public relations. It was gratifying, therefore, to anybody who has the success of this wonderful organization at heart to know that this important item is receiving the attention it deserves.

Throughout the entire week, speakers with rich experience in public utility management and with insight and vision into economic questions expressed their views frankly. The growth of the National Electric Light Association has been marvelous during the 40 yr. of its existence and it has much to be proud of but, as president Davidson pointed out in his opening address, the association must continue its activities in all directions and guard against any lessening of effort because of its present enviable position.

This splendid convention, which drew over eight thousand people to it from all parts of the country, has already been mentioned in the June 1 number of this journal and, while this present report is to be more comprehensive, because of the large number of subjects discussed and the multitudinous activities of the association, only the high points can be touched upon.

EVERY WORKER HAS MORE THAN 4 HP. AT HIS COMMAND

Although the convention began on Monday, May 17, with a number of special sessions of the various committees, it was formally opened on Tuesday morning with an address from the president, J. E. Davidson of Omaha. Mr. Davidson's address, although brief, summarized accurately the activities of the association during the year and showed the importance of the electric light and power industry to civilization. The present enviable position of the United States among nations with respect to national wealth and commercial and industrial supremacy, Mr. Davidson attributed largely to the success of our electric light and power industry.

Electric motors in the United States are doing as much work every day as could be accomplished by 170,000,000 men or four times the 45,000,000 men and women of this country who are engaged in gainful occupations. In other words, every worker has an average of more than 4 hp. at his command, 75 per cent of this power in industry being electrical. Notwithstanding the advance made, much still remains to be done. Mr. Davidson said that in spite of the fact that the number of customers has doubled in the last 6 yr., there still remain more than ten million homes which are not wired for electrical service. Only 10 per cent of the farms are electrified and less than two per cent of the railroad mileage is electrically operated.

An idea of the magnitude of the National Electric Light Association's activities was gained from the report of W. A. Jones, the treasurer. Income from dues amounted to $890,000 and other items built up the sum of $1,707,000 to be accounted for. Total disbursements were $1,024,000.

Managing director M. H. Aylesworth, in his address at the opening session, stressed the industry's obligations to the public and warned the members to consider their increasing responsibilities. The industry serves a larger portion of the population in a greater variety of ways than any other industry and, for that reason, has a proportionately greater responsibility. The problem before the industry at present is the full discharge of a national duty in equipping itself to meet the public need and opening channels for further service. The duty of the utilities, said Mr. Aylesworth, is primarily to make service available rather than to stimulate demands for service.

OWEN D. YOUNG PRESENTS HIS VIEWS

If any one feature of the convention was of more outstanding importance than others it was perhaps the masterly and scholarly address of Owen D. Young, the chairman of the Boards of the General Electric Co. and the Radio Corporation. An audience of four thousand men and women rose to pay him tribute when he came for-

ward to state "his personal views made without consultation with others and spoken in no sense in a representative capacity."

"In my opinion," said Mr. Young, "the difficulties between the public utilities and the public arise from the fact that the public utility managers know too much about their business and the public knows too little about it. If the utilities do something which the public dislikes, even temporarily, it strikes back, often destructively.

"Widespread distribution of utility securities, especially among its own customers," pointed out Mr. Young, "is a way by which such customers may be induced to study the utility problems impartially and open mindedly. May I suggest to utility managers that when they are asking the public to take stock in their enterprises and assume the dual capacity of stockholder and consumer, the managers themselves be careful to see to it that they take stock in public welfare and put themselves in the dual capacity of citizen and operator?"

Mr. Young also touched upon the controversy of public versus private ownership. During the past few years he had had the opportunity of studying and observing the operation of publicly owned enterprises in most of the principal countries of the world. "By and large," he said, "their efficiency in service is markedly less than that of private companies. Indeed, it is scarcely too much to say that the best of the publicly owned enterprises are comparable only with the worst of the privately owned concerns. In many cases, no one but the government would dare to give such inadequate and inefficient service as I have seen."

Rural electrification to Mr. Young seemed inevitable. "Before many years the privately owned company will have discovered how to serve the farmer at a profit and correlatively they will have taught the farmer how to use that service to his profit and better social standing."

Sloan Asks More Attention to Public Relations

In a vigorous address at the first general session on Tuesday, M. S. Sloan, of the Public Relations National Section, called for executive support and greater attention to public relations. He stated that public opinion was now favorable to the industry and that this was true because of the vigorous and efficient work on public relations throughout the country. This, he stated, gave reason for gratification but not for satisfaction. The public relations problem is not yet solved and present conditions call for still greater and more effective effort.

In his address, "What Is the Function of the N. E. L. A.?" R. H. Ballard, vice president of the Southern California Edison Co., flayed socialism and government ownership. The latter he regarded as an insidious form of socialism. "There have been proposals for government ownership of every industry in the country except perhaps that of agriculture. The farmer," said Mr. Ballard, "is probably left out of the public ownership Utopia so that there may be someone on the outside on whom additional taxes can be loaded to offset deficits in government revenue which would be caused by the issuance of an enormous volume of tax-exempt securities for these socialistic schemes."

The convention program differed somewhat this year from that of preceding years in that only one technical session was held. This, upon first thought, might seem unfair to the engineers attending but, when the extremely large number of subjects concerned with the technical committees are considered and the impossibility of discussing them comprehensively in one week, the wisdom of the arrangement can be appreciated. All the reports of the various technical committees are published throughout the year and so, at the national convention, it is only necessary for the respective chairmen to present summaries of their reports, as was done at the convention just held.

Perhaps the chief feature of the Technical Session was the address by John C. Parker on "The Significance of Codes and Standards." In this address, Mr. Parker developed in an admirable manner the whole philosophy of standardization and its social significance from the standpoint of service to the customer. He contended that no code or standard or instruction or operating practice should be made unless tradition and well-tried-out experience had practically established them before they were formally adopted. Another type of code or standard in his opinion might be warranted where a small minority wilfully and stubbornly impeded progress.

Another interesting feature of the Technical Session was the presentation by Chas. B. Scott, chairman of the Accident Prevention Committee, of the Insull medal for life-saving to I. P. Crum, of the Union Gas and Electric Co. Mr. Scott, in his report, stated that the most vital element of accident prevention was now accepted as a major operating problem.

A. D. Bailey, chairman of the Prime Movers Committee, reported no radically new developments in the art but indicated that steady and continuous progress is being made on all aspects of power generation. E. C. Stone, chairman of the Electrical Apparatus Committee, outlined briefly the scope of his committee's work and emphasized the large number of serial reports issued this year.

S. W. Parr presented an extremely interesting paper on the cause and prevention of embrittlement in boiler plates and R. L. Thomas, chairman of the hydraulic power committee, directed attention to the notable survey of the service reliability of hydraulic units made by his committee.

Secretary Davis Speaks at Second General Session

Among the various reports presented at the Second General Session on Wednesday morning, that by E. W. Lloyd, of the Commercial National Section, was of interest. He stated that the industry had been notable for a development by successive cycles of interest and activity and that at this time it was entering upon a cycle of intense commercial development. The commercial goal of the industry, according to Mr. Lloyd, is the complete electrification of America, which requires a competent selling staff and a proper form of rate and pioneering merchandising efforts.

James J. Davis, secretary of the Department of Labor, won the enthusiastic interest of the audience by covering not only the value of good industrial lighting but the general labor situation and the influence of electrical developments on better industrial conditions.

Bruce Barton, another speaker at this session, devoted his attention to the problem of public relations.

"Public relations," he said, "in the future must be viewed from the standpoint of public service and not from a standpoint of self defense."

"John Smith" Speaks at Third General Session

"John Smith" or James Brown, whatever you please to call him, citizen or voter, gave his opinions concerning the electric light and power industry on Wednesday afternoon, using B. C. Forbes as a mouthpiece.

David Sarnoff, vice president of the Radio Corporation, predicted that the volume of radio apparatus and supply sales in this country in 1926 will reach $500,000,000. The only danger confronting the radio industry, he said, is unwise legislation. The complexity of the radio problem makes hasty legal action threatening to the prosperity of this branch of the electrical art. Radio, in Mr. Sarnoff's opinion, was a good field for power companies as radio devices are fast taking their place among equipment consuming power.

Other speakers at this session were John W. Lieb, of the New York Edison Co., who presented resolutions defining central station policy in railroad electrification; W. E. Creed, president of the Pacific Gas and Electric Co., who spoke upon the social and economic aspects of interconnection in California; Guy W. Talbot, who gave facts on electric ranges; Frank Evans, secretary of the American Farm Bureau Federation; and G. C. Neff, of the Rural Electric Service Committee. A spirited dialogue entitled ' Satisfying the Customers" enlivened the proceedings through clever impersonations by Mrs. Ruth Philip Steinhauser and Miss Vanabel Seale. Mrs. Steinhauser showed how to turn an irate customer into a friend and stockholder.

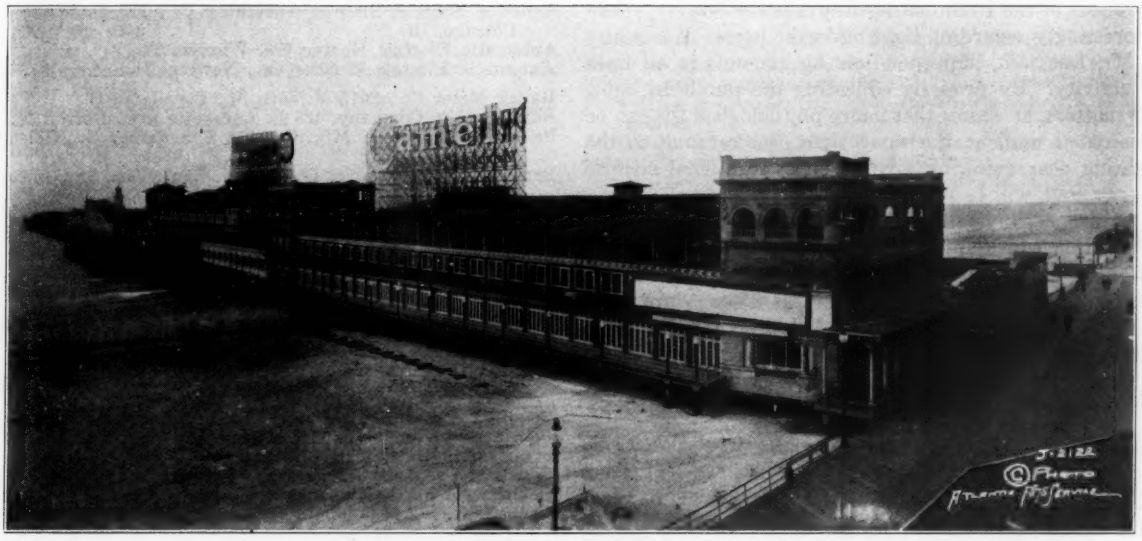
Thomas A. Edison Honored at the Public Policy Meeting

With the public policy meeting on Wednesday night came the climax of the convention program. Music, addresses and dancing made a combination of irresistible appeal. The speeches made by Secretary Mellon and Martin J. Insull, together with the award to the Commonwealth Edison Co. of Chicago, in the presence of Thomas A. Edison, of the Coffin medal for meritorious service lent added interest and dignity to the meeting. Vincent Lopez, the brilliant orchestra leader, and Elizabeth Rethberg, the celebrated prima donna, added touches of artistic entertainment to give color and pleasure to the occasion.

The public policy program was broadcast through WEAF and 13 other broadcasting stations throughout the country, extending as far west as Davenport and Kansas City.

Andrew Mellon, Secretary of the Treasury, who spoke to the audience from Washington, complimented the association on the part it has played in increasing the wealth of the country and in bringing about the far reaching, beneficial economic changes of recent years.

An impressive part of this session was the interruption of Martin Insull's speech by the entrance of Thomas A. Edison, who, accompanied by W. H. Meadowcraft, his secretary, and Mrs. Edison, had motored from East Orange to Atlantic City to attend the convention. As a mark of respect to the Father of the Electrical Industry, Martin Insull in closing asked the audience to rise, and invited Mr. Edison to step to the microphone. It was only after several moments of coaxing that he reluctantly stepped forward and said, smilingly, "This is the first time I have talked over the radio. Good night."



MILLION DOLLAR PIER AT ATLANTIC CITY, N. J., SCENE OF 49TH ANNUAL N. E. L. A. CONVENTION

At the fourth general session on Thursday morning, the principal speakers were Samuel Insull, William Allen White and Mrs. Mary King Sherman, president of the General Federation of Women's Clubs. Mr. White's address was broad and uplifting, touching upon many phases of our economic and social life and commending the activities of the association. Mr. Insull, as usual gave valuable statistics on the use of light and power and outlined the future course of the electrical industry. Mrs. Sherman's talk on "Electrifying the American Home" told of what was being accomplished in removing the burdens from the women of America by the use of electrical appliances and of the part in this work played by the N. E. L. A. She particularly

emphasized the importance of domestic electric refrigeration to the farm household.

Guy E. Tripp Predicts Decentralization of Industry

Decentralization of industry, in the opinion of Guy E. Tripp, Chairman of the Board of the Westinghouse Electric and Manufacturing Co., who addressed the fifth general session, will do much to help the farmer out of his present economic difficulties. Superpower, or the interconnection of electric systems, he stated, would make possible such decentralization because, wherever superpower systems are well developed, power can be secured and small factories can multiply in the rural districts.

Another interesting talk at the fifth general session was that by Alex Dow, president of the Detroit Edison Co. Mr. Dow, in his usual humorous manner, went deep into philosophy and told a number of interesting "fairy tales" which were decidedly to the point.

At the closing session, Friday morning, M. Luckiesh, president of the Illuminating Engineering Society, spoke interestingly regarding lighting in the home. According to Mr. Luckiesh, improper lighting abounds in all lines of activity. By properly educating the public in lighting matters, he claims that many physiological ills can be eliminated and, at the same time, the revenue to the lighting companies, by virtue of the additional electric energy sold, will be materially increased.

As reported in the brief account of the N. E. L. A. convention which appeared in the June 1 issue of Power Plant Engineering, R. F. Pack of the Northern States Power Co., Minneapolis, Minn., was elected president for the ensuing year. M. H. Aylesworth was elected secretary, Percy Young treasurer and J. B. Miller, M. S. Sloan, H. T. Sands, and P. C. Arkwright were elected vice presidents.

Exhibit of Electrical Equipment Surpasses That of Previous Years

The exhibit of electrical equipment held on the Million Dollar Pier was the most comprehensive ever staged. There were 184 individual exhibits, occupying 73,500 sq. ft. Not only were there exhibits of all types of electrical appliances and light electrical equipment, but many lines of heavy power equipment were shown. Fuel burning equipment, soot blowers, oil switches and steel clad mercury arc rectifiers, as well as all types of automatic control and switching apparatus, compelled great interest.

An oil switch for underground network installations was on exhibition and another new type of switchboard equipment shown was the all metal safety type board containing bus bars, oil breakers and accessories completely enclosed in a container.

Underground cable manufacturers showed joints, potheads, cable and junction boxes of improved design. Elevator equipment of the latest type and power factor corrective motors and condensers were shown in action.

One exhibit, by a large construction company, included a model of a complete central station, showing the arrangement of all mechanical and electrical equipment. Carrier current systems for power line communication were installed for demonstration purposes as were also carrier current and selector supervisory control systems.

Exhibits of domestic electric refrigerators were most numerous. This branch of the industry, which a few years ago was relatively unimportant, has expanded to proportions that are truly amazing.

LIST OF EXHIBITORS

49th Convention

NATIONAL ELECTRIC LIGHT ASSOCIATION

Allen-Bradley Company, 286 Greenfield Ave., Milwaukee, Wisconsin
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Altorfer Bros. Company, Peoria, Ill.
Aluminum Company of America, Edgewater, N. J.
American Brass Company, 25 Broadway, New York City
American Brown Boveri Electric Corporation, 165 Broadway, New York City
American Electrical Heater Company, 6125 Woodward Ave., Detroit, Mich.
American Ironing Machine Company, 100 E. Ohio St., Chicago, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.
Anaconda Copper Mining Co., 25 Broadway, New York City
Anderson, Albert & J. M., Manufacturing Co., 135 Broadway, New York City
Armstrong Mfg. Company, The, Huntington, W. Va.
Asbestos Shingle, Slate & Sheathing Co., 319 N. Wells St., Chicago, Ill.
Automatic Electric Heater Co., Warren, Pa.
Automatic Electric Washer Co., Newton, Ia.

Bailey Meter Co., 2015 E. 46th St., Cleveland, O.
Bartlett Mfg. Company, 428 E. Lafayette Ave., Detroit, Mich.
Beardslee Chandelier Mfg. Co., 216 S. Jefferson St., Chicago, Illinois
Benjamin Electric Mfg. Co., 120 S. Sangamon St., Chicago, Illinois
Blaw-Knox Company, P. O. Box 915, Pittsburgh, Pa.
Bradley Washfountain Company, 2203 Sycamore St., Milwaukee, Wis.
Burroughs Adding Machine Co., Detroit, Mich.

Chance Company, Centralia, Mo.
Clark-Williams Engineering Co., 886 Main St., Bridgeport, Connecticut
Clements Mfg. Company, 601 Fulton St., Chicago, Ill.
Combustion Engineering Corporation, 43 Broad St., New York City
Condit Electrical Mfg. Corp., South Boston, Mass.
Continental Valve & Equipment Co., 82 Herbert St., Framingham, Mass.
Copeland Products, Inc., 630 Lycaste St., Detroit, Mich.
Copperweld Steel Company, Braddock P. O., Rankin, Pa.
Cramer, R. W., & Company, Inc., 136 Liberty St., New York City
Crane Company, 836 S. Michigan Ave., Chicago, Ill.
Crane Packing Company, 1800 Cuyler Ave., Chicago, Ill.
Curtis Lighting, Inc., 1119 W. Jackson Blvd., Chicago, Ill.

Dampney Company of America, The, 50 Business St., Boston 36, Mass.
Davis Emergency Equipment Co., Inc., 67 Wall St., New York City
De Laval Separator Company, 165 Broadway, New York City
Delco-Light Co., 285 Madison Ave., New York City
Delta-Star Electric Co., 2400 Block, Fulton St., Chicago, Ill.
Deming Manufacturing Co., The, 5103 Lakeside Ave., Cleveland, O.
Diamond Expansion Bolt Co., 90 West St., New York City
Diamond Power Specialty Corporation, P. O. Box 851, Detroit, Mich.
Doble Engineering Co., Medford Hillside, Mass.
Dover Mfg. Co., The, Dover, O.
Duncan Electric Mfg. Co., Lafayette, Ind.
Duparquet, Hout & Moneuse Co., 108 West 22nd St., New York City

Earnshaw Manufacturing Co., 128 S. 19th St., Philadelphia, Pennsylvania
Edison Electric Appliance Co., Inc., 5600 W. Taylor St., Chicago, Ill.
Edison, National & Westinghouse Lamp Cos., Harrison, N. J.
Edison Storage Battery Co., Orange, N. J.
Electric Household Utilities Corp., 54th and 22nd Sts., Chicago, Ill.
Electric Power Equipment Corporation, 412 N. 18th St., Philadelphia, Pa.
Electric Refrigeration Corporation, 2051 W. Fort St., Detroit, Michigan

Electric Service Supplies Co., 17th and Cambria Sts., Philadelphia, Pa.
Electric Storage Battery Co., Allegheny Ave. and 19th St., Philadelphia, Pa.
Electric Truck Manufacturers Association, 300 Hunting Park Ave., Philadelphia, Pa.
Electric Vacuum Cleaner Co., Inc., 1734 Ivanhoe Rd., Cleveland, O.
Electrical Record, Gage Publishing Co., 461 Eighth Ave., New York City
Elliott-Fisher Co., 342 Madison Ave., New York City
Engineering Products Corporation, Room 309, 25 Church St., New York City
Erie Malleable Iron Co., Kondu Division, Erie, Pa.
Eureka Vacuum Cleaner Co., 25 W. 43rd St., New York City
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Federal Electric Co., 130 W. 42nd St., New York City.
Federal Gauge Co., The, 25 Church St., New York City
Forbes, B. C., Publishing Co., 120 Fifth Ave., New York City
Four Wheel Drive Auto Co., The, 50 W. 145th St., New York City
Fuller-Lehigh Co., Fullerton, Pa.
G & W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.
Gainaday Electric Co., 30th St. and Liberty Ave., Pittsburgh, Pennsylvania
General Electric Co., Schenectady, N. Y.
General Necessities Corporation, General Necessities Bldg., Detroit, Mich.
Gest, G. M., 1336 Woolworth Bldg., New York City
Giant Manufacturing Co., Council Bluffs, Ia.
Gillinder Brothers, Inc., Port Jervis, N. Y.
Gould Storage Battery Co., Inc., 250 Park Ave., New York City
Graybar Electric Co., 100 E. 42nd St., New York City
Groundulet Co., 86 Park Pl., Newark, N. J.
Gruber Brothers, 392 Broadway, New York City
Habirshaw Cable & Wire Corp., 10 E. 43rd St., New York City
Hirschy Company, The, 259 S. First Ave., E., Duluth, Minn.
Holophane Glass Company, 342 Madison Ave., New York City
Hoosier Engineering Co., 325 S. New Jersey St., Indianapolis, Indiana
Hoover Company, The, 1407 Railway Exchange, Chicago, Ill.
Hubbard & Company, 6301 Butler St., Pittsburgh, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City
International Nickel Co., 67 Wall St., New York City
Iron Mountain Co., 5042 Cedar Ave., Philadelphia, Pa.
Iroquois Electric Refrigeration Co., 1600 Arch St., Philadelphia, Pa.
Johns-Manville, Inc., 292 Madison Ave., New York City
Johns-Pratt Co., Hartford, Conn.
Kerite Insulated Wire & Cable Co., 30 Church St., New York City
Kuhlman Electric Co., Bay City, Mich.
Laconia Car Company, 60 Congress St., Boston, Mass.
Landers, Frary & Clark, New Britain, Conn.
Landis & Gyr, Ltd., 104 Fifth Ave., New York City
Leeds & Northrup Company, 4901 Stanton Ave., Philadelphia, Pennsylvania
Liberty Electric Corporation, Stamford, Conn.
Lidgerwood Mfg. Co., 96 Liberty St., New York City
Lighting Fixtures and Lighting, 215 Fourth Ave., New York City
Lindemann & Hoverson, A. J., Company, 1st and Cleveland Aves., Milwaukee, Wis.
Line Material Company, South Milwaukee, Wis.
Locke Insulator Corporation, South Charles and Cromwell Sts., Baltimore, Md.
Lunkenheimer Company, The, Cincinnati, O.
Majestic Electric Appliance Co., 1705 Allegheny Ave., Philadelphia, Pa.
Manning, Bowman & Company, 200 Fifth Ave., New York City
Manning, Maxwell & Moore, Inc., 100 E. 42nd St., New York City
Marquiz, M., 1018 S. Wabash Ave., Chicago, Ill.
Mathews, W. N., Corporation, 3722 Forest Park Blvd., St. Louis, Mo.
McGraw-Hill Co., Electrical World, 36th St. and 10th Ave., New York City
Memco Engineering & Mfg. Company, 381 Hamilton St., Long Island City, N. Y.
Metropolitan Device Corporation, 1250 Atlantic Ave., Brooklyn, N. Y.
Moloney Electric Co., St. Louis, Mo.
National Lead Company, 111 Broadway, New York City
Niagara Electric Improvement Corporation, % R. W. Lillie Corp., 50 Church St., New York City
Ocean Accident & Guarantee Corp., Ltd., 1 Park Avenue Bldg., New York City
Ohio Brass Company, Mansfield, O.
Okonite Company, The, Passaic, N. J.
Otis Elevator Co., 260 Eleventh Ave., New York City
Packard Electric Co., 621 Penton Bldg., Cleveland, O.
Palmer Electric & Mfg. Co., 175 Fifth St., E., Cambridge, Mass.
Peerless Insulated Wire & Cable Co., 90 West St., New York City
Permutit Company, The, 440 Fourth Ave., New York City
Philadelphia Storage Battery Co., Ontario and C Sts., Philadelphia, Pa.
Pittsburgh Transformer Co., Pittsburgh, Pa.
Porter & Ross, Inc., 30 Church St., New York City
Power Plant Engineering, Technical Publishing Co., 53 W. Jackson Blvd., Chicago, Ill.
Public Service Electric and Gas Company, 80 Park Pl., Newark, N. J.
Public Service Production Co., 80 Park Place, Newark, N. J.
Radio Corporation of America, 233 Broadway, New York City
Rainbow Appliance Corporation, 11 Hand St., Rochester, New York
Remington Typewriter Co., 374 Broadway, New York City
Robeson-Rochester Corporation, 176 Anderson Ave., Rochester, N. Y.
Russell Electric Co., 340 W. Huron St., Chicago, Ill.
Sangamo Electric Co., 50 Church St., New York City
Savage Arms Corporation, 100 E. 42nd St., New York City
Schweitzer & Conrad, Inc., 4435 Ravenswood Ave., Chicago, Illinois
Scovill Manufacturing Co., Waterbury, Conn.
Seeger Refrigerator Co., St. Paul, Minn.
Servel Corporation, The, % R. D. Lillibridge, Inc., 8 W. 40th St., New York City
Sewickley Electric Mfg. Company, Sewickley, Pa.
Simplex Electric Heating Co., 85 Sidney St., Cambridge, Mass.
Smith Home Appliances, Inc., Syracuse, N. Y.
Smoot Engineering Corporation, 136 Liberty St., New York City
Square D Company, 6060 Rivard St., Detroit, Mich.
Standard Oil Company (New Jersey), 26 Broadway, New York City
Standard Underground Cable Co., 17th and Pike Sts., Pittsburgh, Pa.
States Company, The, 19 New Park Ave., Hartford, Conn.
Superheater Company, The, 17 E. 42nd St., New York City
Syracuse Washing Machine Corporation, 270 Madison Ave., New York City
Swartzbaugh Mfg. Co., 1501 W. Bancroft St., Toledo, O.
Thomas, The R., & Sons Company, East Liverpool, O.
Transelectric Company, 518 Traction Terminal Bldg., Indianapolis, Ind.
Trumbull Electric Mfg. Co., Plainville, Conn.
Truscon Steel Co., Youngstown, O.
U G I Contracting Co., Broad and Arch Sts., Philadelphia, Pennsylvania
United Electric Company, 1230 Eighth St., N. E., Canton, O.
Utilities Publication Committee, Munsey Bldg., Washington, D. C.
Utilities Publication Company, 431 S. Dearborn St., Chicago, Illinois
Valley Refrigeration Works of the Peerless Husker Co., 501 Cornwall Ave., Buffalo, N. Y.
Wagner Electric Corporation, % R. D. Lillibridge, Inc., 8 W. 40th St., New York City
Wahle, Albert, Company, Metropolitan and Morgan Aves., Brooklyn, N. Y.
Walker & Pratt Mfg. Co., 31 Union St., Boston, Mass.
Wall, P., Mfg. Supply Co., 3126 Preble Ave., N. S., Pittsburgh, Pa.
Walworth Company, 44 Whitehall St., New York City
Waters-Genter Co., 213 N. Second St., Minneapolis, Minn.
Welsbach Company, Gloucester, N. J.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 4 Haynes Ave., Newark, N. J.
Wheeler Mfg. Co., C. H., Lehigh and Sedgley Aves., Philadelphia, Pa.
Winston, Inc., 360 N. Michigan Ave., Chicago, Ill.
Wolcott, Frank E., Mfg. Company, 74 Union Pl., Hartford, Connecticut
Woodrow Manufacturing Co., Newton, Ia.
Wright, M. S., Company, Worcester, Mass.

Lubrication of Materials Handling Equipment

PROPER SELECTION OF LUBRICANT TO FIT THE WORKING CONDITIONS AND PROPER APPLICATION TO GEARS, BEARINGS AND WIRE ROPE INCREASE EFFICIENCY

MANY of the repairs or replacements necessary on the average crane, hoist, or car dumper can be attributed to lack of proper lubrication. Such equipment is massive; the wearing elements such as gears, chains, bearings and wire rope are located in more or less inaccessible places; practically all are exposed to the weather, and dust or dirt is always present.

In some one of its many varieties ranging from the crudest form of jib crane to the most modern overhead traveling device, as shown in Figs. 1 and 2, the electric

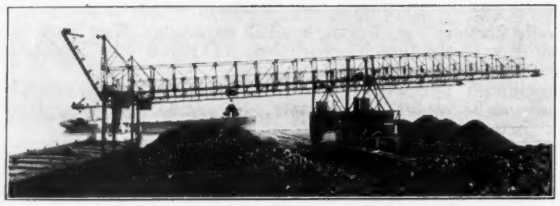


FIG. 1. TWO CONVEYOR BRIDGES HANDLING COAL AT A DOCK ON LAKE SUPERIOR

crane is a vital factor in practically every industry where bulky materials or products must be moved with precision, rapidity and expedience. Crane service is perhaps the most varied of any materials handling equipment. Where one crane may operate under cover in an atmospheric temperature of 100 deg. F., directly adjacent there may be a similar device in the yard, operating exposed to the weather. Bearing lubrication, under such conditions on an out-door crane, says Lubrication,* may require oils of low pour test and comparatively low viscosity to insure the maintenance of an effective lubricating film, and the reduction of the possibility of congealment in the oil reservoirs. In effect, an oil of at least zero degrees pour test and approximately 200 sec. Saybolt viscosity at 100 deg. F. would be required. While such a pour test would be immaterial in the case of lubrication of crane bearings in adjacent buildings, the viscosity would in all probability be too low, especially if the crane operates adjacent to heat appliances or furnaces.

It must be borne in mind that, on most materials handling equipment, few provisions for bath or enclosed lubrication are possible. As a result, the maximum of protection is absolutely necessary from a lubricating point of view.

To stop with careful selection of lubricants would leave the job but half done. Quite as much attention is necessary from the viewpoint of application and handling of oils and greases. For this reason progressive plants, as a rule, will insist on a regular lubrication schedule, in many cases holding individual operators directly responsible for the efficiency of operation of their respective machinery.

In the handling of coal and other products from cars to storage yards or bins, the motor-driven car dumper or unloader is a valuable piece of equipment due to the ease, rapidity and economy with which it accomplishes an otherwise dirty job. In construction the car dumper, as shown in Fig. 3, involves a structural steel frame, which carries a cradle or cage in which the car is held during the process of unloading. By means of an automatic clamping arrangement the car is held rigidly in this position, being tilted sufficiently to empty the contents, or completely overturned, according to the design.

Machinery of this type must be massive, for gross loads of up to perhaps 100 t. must be carried with speed, safety and reliability. In consequence the operating mechanisms are designed with the utmost care. The necessarily large gears, heavy bearings and other equipment which this involves, place an unusual responsibility upon the operator after such a machine is installed, due to the exacting lubricating requirements. Figure 4 shows a detail of a supporting trunnion of a car dumper.

To meet these conditions the lubricants employed must be so refined as to maintain a lubricating film capable of resisting any squeezing out action, and also with adequate

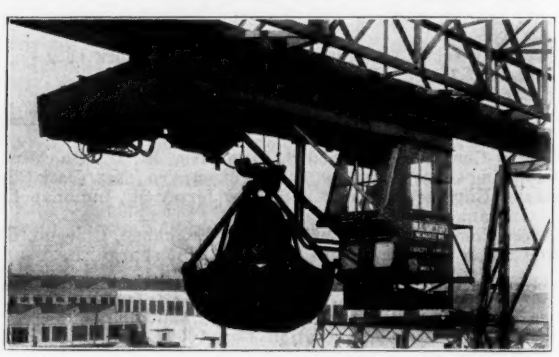


FIG. 2. GRAB BUCKET, USED ON EITHER MONORAIL OR CRANE, PRESENTS PROBLEMS OF MOTOR, GEAR AND ROPE LUBRICATION

fluidity and low pour test to function under low temperature conditions.

MOTOR LUBRICATION IS AN IMPORTANT FACTOR

The fact that materials handling equipment of this nature is, as a general rule, electrically driven, renders the electric motor of especial interest. The operating efficiency of such machinery, in many instances, will be largely contingent upon the efficiency of its driving motors. In fact, any failure of the latter to function according to their rating may materially affect those operations which they are supposed to maintain.

Motors equipped with ring oiled bearings will, under average or low temperature conditions, require an oil from 180 to 200 sec. Saybolt at 100 deg. F. To meet the possibility of operation in cold weather, in the handling of outdoor cranes, car dumpers and ore bridges, this oil should have as low a pour test as possible to insure against congealment or sluggish flow which might materially affect circulation of the oil by the rings, with consequent overheating of the bearings.

On the other hand, where motors with similar bearings must function under conditions of comparatively high radiated heat as, for example, in many parts of the steel

*Published by the Texas Co., New York.

mill, it has been found more practicable to use an oil of somewhat higher initial viscosity, ranging from 300 to 500 sec. Saybolt at 100 deg. F. Where electric motors are equipped with ball or roller bearings, grease must also be considered.

Lubrication of Wire Rope

Wire rope lubrication is one of the most important factors in any plant where materials in bulk, such as ore, coke or coal are to be handled, for the ultimate efficiency of operation, to a large extent, depends upon the condition of the cables or wire ropes. It is not enough to assume that because such ropes come from the manufacturers in a lubricated state, being in general wound on an oil-saturated core, that further lubrication is unnecessary.

The matter of friction between the strands of a wire rope is essentially the same as friction between a bearing and shaft. Over-heating and abnormal wear will practically always result in reducing the load carrying capacity and increasing the amount of power consumed in operation. This can only be overcome by effective lubrication, brought about by the proper application of a suitably prepared wire rope compound, which will not only be capable of penetrating to the innermost strands and core of the rope, but

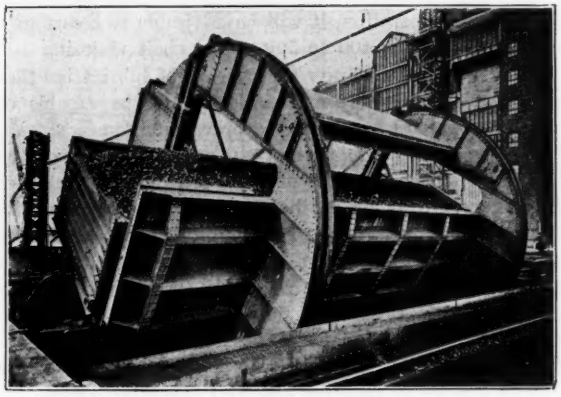


FIG. 3. CAR DUMPER, OFTEN USED IN UNLOADING COAL, REQUIRES PROPER LUBRICATION ON ACCOUNT OF HEAVY LOADS HANDLED

will also be sufficiently adhesive and viscous to resist being prematurely squeezed out or washed off by rain.

Essentially a wire rope lubricant, in addition to the properties mentioned above, must not tend to cake, gum or ball up, especially if contaminated with an excess of dust, dirt or metallic particles. Furthermore, it must be resistive to the thinning-down effects of higher temperature.

Proper Viscosity for Wire Rope Lubricant

According to the operating temperatures that may be involved, and the possibility of the presence of an excess of water, the viscosity of a wire rope lubricant should be 1000 sec. Saybolt at 210 deg. F. or somewhat lower. In warm climates, adjacent to ovens, furnaces, etc., where there might be possibility of such a product thinning down to the extent of dripping off, resulting in lack of lubrication, it will be advisable to use a lubricant of approximately 1000 sec. viscosity, in accordance with the temperature prevalent. On the other hand, under relatively cold conditions, as might be involved adjacent to the Great Lakes, in Canada or the Northwest, it would be advisable to use a somewhat thinner product, again in accordance with the range of operating temperatures involved.

Wire rope lubricants to meet the aforesaid requirements should, in general, be straight mineral petroleum products, devoid of fillers or thickening mediums. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which cannot be depended upon.

Applying Lubricant to Wire Rope

A satisfactory method of treating wire ropes is to use a form of box as illustrated in Fig. 5, according to the angle of the rope in question. Such a box can be readily

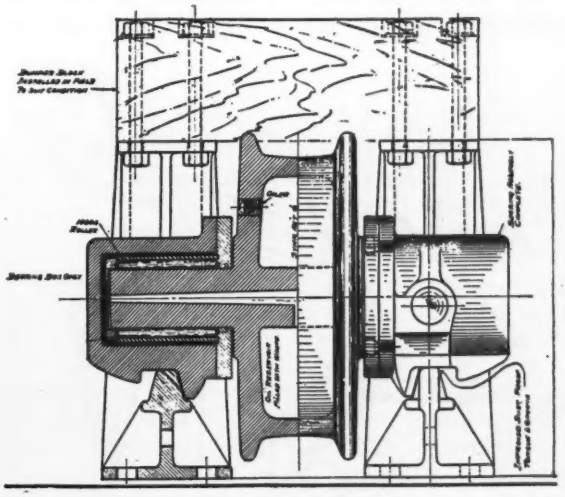


FIG. 4. IN THIS CAR DUMPER SUPPORTING TRUNNION, OIL IS FORCED INTO RESERVOIR INSIDE TRUNNION AND PASSES THROUGH HOLLOW SHAFT TO ROLLER BEARINGS

built in the average plant, with suitable provision for rendering it sufficiently tight to prevent the lubricant from leaking out even when reduced in viscosity by heating. The slow passage of the rope through such a bath of heated compound will insure that not only will the surface be coated, but also that the requisite penetration takes place at the inner strands. Further working of the rope over the sheaves before the lubricant has time to cool entirely will tend to aid in bringing about the maximum of penetration.

Characteristics of Gear Lubricants

In certain types of materials handling machinery, gears and chains in certain cases, will be enclosed, but in many others they will be exposed to the elements. Such gears also frequently operate in an atmosphere of abrasive dust and dirt which will tend to penetrate the lubricating film on the teeth, or become mixed with any excess of this product to act in much the same manner as a valve grinding compound.

In the selection of suitable lubricants to meet such conditions, there are four distinct characteristics that require consideration, viz:

1. the viscosity, which should be commensurate with the method of lubrication, the amount of heat that may be encountered and the pressures involved between the teeth;

2. sufficient "oiliness" or lubricating ability in order that abnormal power losses may not accrue due to solid and fluid friction;

3. a maximum of adhesiveness in order that the lubricant, when used under exposed or semi-enclosed conditions, will maintain a sufficient film on the teeth and effectively resist the action of centrifugal force;

4. the least tendency to crack, congeal or harden.

Automatic Lubricators for Oil and Grease

Even more inaccessible than gears, or wire rope cables are the bearings which carry much of the shafting involved. As a general rule, they are comparatively large and subjected to conditions of operation wherein some form of automatic lubrication is practically mandatory.

For this purpose where oil lubrication is desired or essential, some form of sight feed drip cup, waste pad oiler,

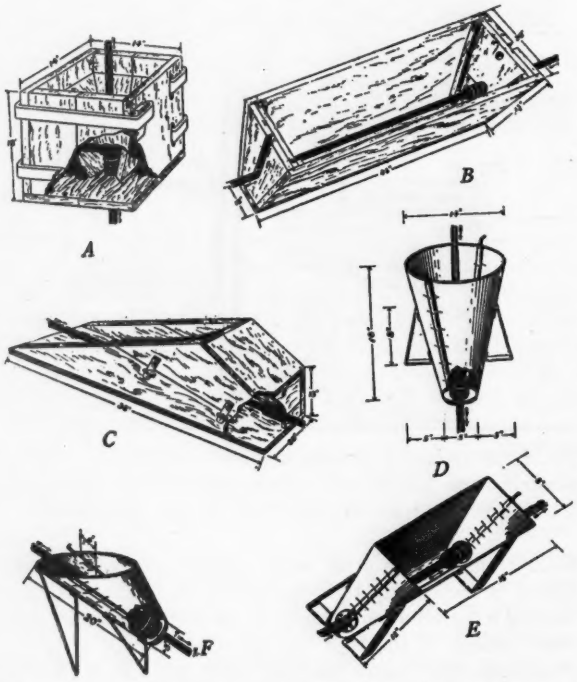


FIG. 5. BOXES FOR LUBRICATING AND TREATING WIRE ROPE. A, FOR VERTICAL ROPE; B, FOR HORIZONTAL ROPE AND C, FOR ROPE AT ANGLE, ARE OF WOOD; D, E AND F, ARE SIMILAR BOXES OF METAL

or ring oiling system is usually employed in connection with plain bearings. Where ball or roller bearings are involved, however, as is true with certain types of crane motors, their lubricating systems form part of the bearings themselves. In such cases, especially where bearings are oil-tight and dust-proof, one charge of oil or grease will insure effective and automatic lubrication for several weeks, according to the intensity of operation and the capacity of the bearing for the lubricant in question.

Sight feed drip cups, if properly installed, are in general dust-proof, oil-tight and automatic just as long as they contain sufficient oil to feed to the bearings. In many cases, however, they will require manual adjustment, and in practically every instance their re-filling will necessitate shut-down of at least part of the machine. These facts may be objectionable, especially where such cups are located on outboard bearings which might be difficult and dangerous for the operator to reach. Furthermore, oil cups will require re-filling at comparatively frequent intervals.

Waste pad or wool yarn oiling systems are also used on the bearings of certain electric cranes, hoists, ore bridges, and other such equipment. The oil for such systems may be either a grade of car oil refined to meet climatic conditions, or a straight mineral machine oil, according to the location and type of reservoir or oil well. In any case, it should have a sufficiently low pour test to insure proper fluidity in cold weather. As a general rule, under conditions involving operation much below 40 deg. F., an oil of some 400 to 500 sec. Saybolt viscosity will serve the purpose. In warm weather a heavier-bodied lubricant of from 750 to 1000 sec. viscosity will, in general, meet the average requirements of waste pad or journal box lubrication.

Ring oilers, in turn, constitute the means of lubrication on many other bearings. Of any, these are perhaps the most nearly automatic, being capable of operating for several weeks without attention or re-filling. Where bearings of this nature function under normal conditions, a medium viscosity straight mineral machine oil of from 180 to 200 sec. Saybolt will, in general, give the best results. Under higher temperatures, however, or in event of low speed and high pressure operation, it will be advisable to resort to a heavier oil of from 400 to 500 sec. Saybolt viscosity.

In view of the necessity for a means of lubrication that will function relatively automatically and be capable of withstanding the hard knocks so prevalent in such service, the grease cup is also extensively used on many of the shafts and sheave bearings of the electric crane, unloader and other equipment of this nature. Such lubricators may become clogged when functioning in an atmosphere of dust and dirt, therefore it is advisable to clean them out and flush the bearings regularly to prevent accumulations of foreign matter therein. Inasmuch as such lubricants must frequently function under water conditions, they must, of course, be compounded from the highest grades of mineral oils and insoluble soaps.

According to a power survey just completed by the National Electric Light Association, a total of 269 American cities that formerly operated their own electric lighting plants, closed down or sold these plants to private companies during the past year. The survey went into the reasons for failure of municipal ownership in these cases. It found that the biggest reason for failure was the enormous advance in the art of manufacturing electricity made in the industry as a whole. The survey also states that, while municipal plants stood still, private plants installed new equipment enabling them to get from a ton of coal three times as many kilowatts of electricity as the average municipal plant obtained. The development of interconnected power systems was another contributing factor, as it was often possible for a municipality to contract for power from a large central station at lower rates than the cost of production in its isolated plant.

An increased capacity of 1 per cent is obtained for every 5 deg. reduction in temperature of the intake air to the compressor.

Propeller Turbine Aids Low Head Developments

High Specific Speeds Decrease First Cost and Increase Output of Turbine at Reduced Heads. By John S. Carpenter

POWER GENERATED being a salable commodity according to the laws of business, the costs of generation of any power whatever must not exceed the price that power can be purchased for or the development will bring sorrow instead of dividends. The high speed hydraulic turbine is the great factor that has made many low head water power sites financially profitable.

First cost and, proportionately, the fixed charges of electrical generators decrease quite rapidly as their revolutions per minute are increased so it is advisable to use the highest speeds that good engineering practice allows. When we use the term "high speed" in reference to water turbines we mean that the horsepower capacity under one foot head for a given size turbine runner is large compared to the speed under the same head. The square root of the horsepower under one foot head multiplied by the r.p.m. under that head gives a quantity called the specific speed. This figure varies from about 15 as a low limit, for heads up to about 800 ft., to a tentative present limit of about 200 for heads up to about 25 ft. If these points are plotted

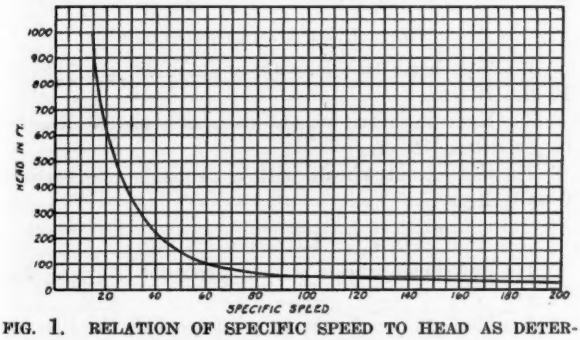


FIG. 1. RELATION OF SPECIFIC SPEED TO HEAD AS DETERMINED BY SAFE OPERATING PRACTICE

on a curve, as in Fig. 1, they will look something like the expansion curve of a steam engine indicator diagram. Experience has determined this as a sort of boundary beyond which it is not wise to go. Some manufacturers will stay below it and others will go beyond at their risk.

High Draft Heads Cause Pitting

As to why it is perilous to go beyond the approximate limits indicated, it may be said that in such cases the runner vanes become pitted, as it is technically called, because air held in the water is decomposed. Nascent or "raw" oxygen is released and attacks the metal of the vanes very severely. Oxygen in this state is especially corrosive, much more so than atmospheric oxygen combined with other gases of the air. It is claimed that the pitting is primarily due to high draft heads, which, combined with the high specific speed, is true due to the desire to place the turbine as high above the tailwater as possible. Not all the different matters connected with pitting and erosion are as definitely settled as they might be, so we use data shown by experience to be safe.

In its present state of development, the Francis type of runner is useful up to a specific speed of about 130; while the so-called propeller type has no definitely known limit, having attained specific speeds of 220 with fair efficiency.

Efficiency curves of these high specific speed turbines show that they are best suited for operation within

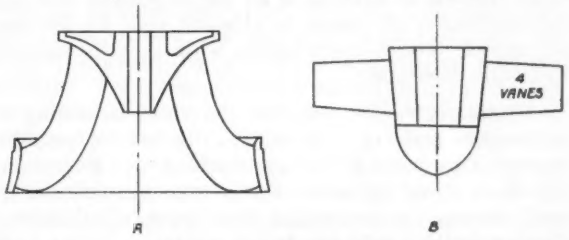


FIG. 2. A COMPARISON OF THE HIGH SPEED FRANCIS TYPE (A) AND THE NEW PROPELLER TYPE (B) RUNNERS SHOWING THE DIFFERENCE IN DESIGN

a comparatively limited range, as the efficiency falls off rather fast on both sides of the maximum value; however, they possess extremely valuable features in that they can operate at varying heads to much better advantage than the slower speed types. A specific case is illustrated in Fig. 3, showing the power output of a 75 specific speed and a 170 specific speed turbine under a condition of falling head. During the flood season of the year the water level in the river rises, the effective head is reduced to a mere fraction of its normal value and the power output is reduced. It is, of course,

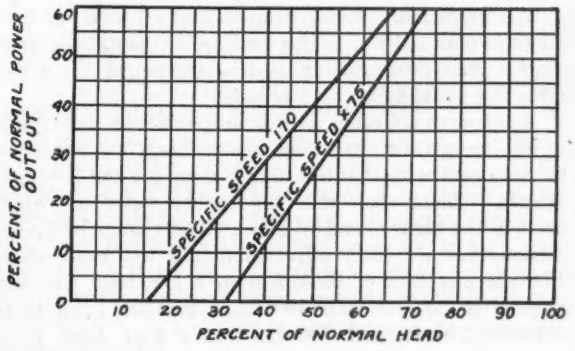


FIG. 3. THE POWER OUTPUT OF LOW SPEED RUNNERS FALLS OFF RAPIDLY AS THE HEAD IS REDUCED

necessary to "stay on the line" as long as possible before shutting down and we see that the 75 specific speed turbine would be producing no power when the head got down to 32 per cent of its normal value, while the 170 specific speed turbine would be going strong and lay down only when the head went down to 16 per cent of its normal amount. Advantages of the high speed, low head turbine are apparent. It is now easy to see why plants with flood conditions prominent in their operation find the use of these high speed turbines a salvation.

High Runaway Speed Peculiarity of Propeller Type Runner

What special factor is responsible for this feature? It is the peculiarity of the high speed turbine—a high runaway speed factor. In the first place, in order to design an efficient high speed runner, one must be particularly careful to reduce as far as possible the idle wetted surfaces that must be dragged through the water. Actual design of the vanes is a complicated process, notwithstanding the fact that they look very natural and of gradual contour to the layman. A strict theoretical analysis is all but impossible and the full perfection of design is attained only by the use of correct theory co-operating with a well-equipped hydraulic laboratory.

By this it will be seen that the water is tending to approach a state of critical flow. It has not actually reached that point but is approaching it. Exceptionally high speed turbines of this type are principally used abroad. In developing these types, a well-known German builder told the writer that on a given test the model may give a certain efficiency but in a fresh test after a few hours' stop with all conditions apparently the same, the new efficiency may be anything within 5 per cent above or below the former test value. This shows that the flow through such types is not stable and has been further shown to exhibit queer governing characteristics, to the extent that the normal amount of flywheel effect used with slower speed runners, is just about half enough. Most American builders are opposed to such high speed for reasons easily discerned. It is possible to go too far in reducing the wetted surface, so this is just one more point in the design that theory does not define and tell us where to stop.

High runaway speed values of the high speed propeller type of runner, often 2.5 times normal r.p.m., have compelled the generator builders to increase greatly the strength of their rotors to withstand the high centrifugal forces. This has increased the cost of generators, so in buying used generators to connect to such turbines, the matter of safety at runaway speed should be investigated carefully.

Pitting of Hydraulic Turbine Runners

Total Draft Head Forms Greatest Single Factor in Determining Its Absence or Occurrence*

PITTING of hydraulic turbine runners has become a matter of considerable concern to turbine users and manufacturers. Authentic and comprehensive information on the subject has hereto been lacking, so a study was made, first, to collect actual experience data from operating companies in the United States and Canada and, second, to classify and analyze these data in such fashion as to throw some light on the causes of pitting and means of its prevention.

All types and sizes of runners and all kinds of metals have been subject to this pitting, or cavitation, process, the term pitting being used to distinguish the action from the usual types of corrosion.

Data were collected on 225 units and, in classifying, it was recognized that high head wheels are subjected to more severe mechanical action than are the low head wheels. Then, too, with the higher velocities which exist in the higher head wheels a given change of bucket contour has a greater effect than in a low head wheel. For the purposes of classification a low head was considered to be less than 100 ft., a medium head to be between 100 ft. and 400 ft., and a high head to be greater than 400 ft.

The wheels were assigned to three classifications as to rate of pitting on the following basis which assumes no repairs:

Class A—No Pitting

1. Low head wheels with a probable life greater than 20 yr.
2. Medium head wheels with a probable life greater than 16 yr.
3. High head wheels with a probable life greater than 12 yr.

Class B—Moderate Pitting

1. Low head wheels with a probable life between 10 and 20 yr.
2. Medium head wheels with a probable life between 8 and 16 yr.
3. High head wheels with a probable life between 6 and 12 yr.

Class C—Excessive Pitting

1. Low head wheels with a probable life less than 10 yr.
2. Medium head wheels with a probable life less than 8 yr.
3. High head wheels with a probable life less than 6 yr.

The wheels in each class were then arranged in three groups according to their size. Runners up to 48 in. in diameter were put first, then runners up to 96 in. in diameter, while all runners over 96 in. in diameter were put in the last group. This was done to show, if possible, whether or not there is a definite tendency of the larger diameter wheels to pit at lower total draft heads than the smaller runners. The above classification results in nine groups of wheels.

When collected, the data were used to prepare the accompanying curve. While at first glance the points appear to be widely scattered, a closer inspection shows them to be more consistent than might be expected in view of the character of the data and the omission from consideration of many variables, usually minor in effect, but which should nevertheless be included to obtain the true draft head on the runner blade.

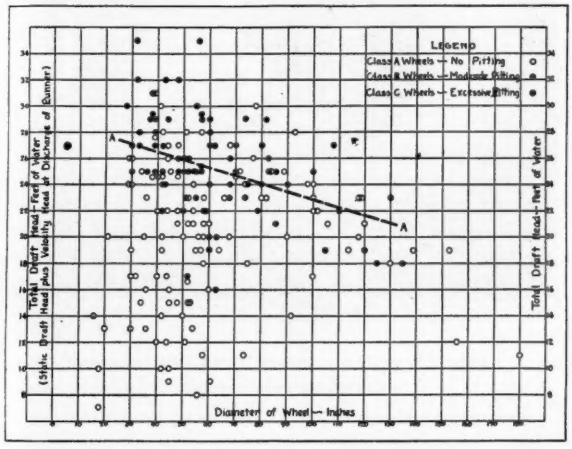
Observations which may be made from the graph are, first, that when the total draft head as computed in this report exceeds a certain critical figure, there is likelihood of serious pitting; second, that when the total

*Abstract of report by the subcommittee of the Hydraulic Power Committee of the N. E. L. A., 1925-1926.

draft head is low, it is almost certain that the runner will not pit, and third, that there is a definite reduction in the safe total draft head allowable in the larger wheels as compared with the smaller wheels.

While the line "AA" does average the points showing moderate pitting, it was not intended to establish a definite limit beyond which it is not safe to go in future designs. A poorly designed wheel can be set with a low height above tail water and show no pitting at all, while a perfectly designed wheel may be set so high above tail water as to make it impossible to avoid pitting.

Returns show that pitting is not confined to runners in either the high or the low head classes, or to high or low specific speed wheels, or to runners having high specific speed with respect to head. Cast iron, cast steel, steel plate, bronze and monel metals all have developed pitting. There does, however, appear to be a definite advantage in the use of bronze for high head wheels which may be due to the possibility of obtaining smoother or more uniform castings rather than the resistance of the metal itself to corrosion.


Legend
Class A Wheels — No Pitting
Class B Wheels — Moderate Pitting
Class C Wheels — Excessive Pitting
A
A
Total Draft Head—Feet of Water (Static Draft Head plus Velocity Head at Discharge at Runner)
Total Draft Head—Feet of Water
Diameter of Wheel — Inches

RELATION OF DRAFT HEAD AND WHEEL DIAMETER TO PITTING IN TURBINE RUNNERS

The chief factor in determining the absence or occurrence of pitting is draft head while it is believed that the active agent in the process is oxygen released from the water to become highly concentrated in the cavities or vacuous spaces. As one manufacturer states, "there is no question whatsoever but that the absolute vacuum on the discharge side of the runner is the greatest single factor influencing pitting, exceeding by a considerable margin, the effect of specific speed, which was formerly outlined as the leading, if not the sole, cause."

Any factor which increases the total draft head at points on the runner surface increases the danger of pitting. Thus we have the following factors which tend toward more pitting: (1) higher specific speed, which means higher velocities in the runner and draft tubes: (2) increased capacity; (3) higher head; (4) better draft tube efficiencies; (5) lowering of the tailwater level; (6) design of the runner as to bucket size, angle and curvature as affecting the local tendency of the stream to pull away from the buckets.

Draft heads at which a vacuum will form depend upon the barometric pressure and the temperature of the water. A reduction of barometric pressure due to high altitudes will reduce the draft head at which pitting will occur and increase the danger. A combination of high altitude, high temperature and low barometric pressure may produce pitting at draft heads several feet less than usual.

Electric arc welding seems to be the most successful method of building up the pitted area and minimizing this action although one company reports considerable success with the oxyacetylene process on bronze runners. Various kinds of cements, paints and metal spraying processes have been tried out with scant success. Neat cement and type metal seem to be the best of these although they are not to be compared with arc welding. Some manufacturers have furnished runners with removable pitting plates and others have tried the experiment of drilling holes in the vanes, from the pressure to the vacuum side, with the idea of relieving the vacuum on the lower side of the bucket.

Pitting is not confined to hydraulic turbine runners. The same type of pitting that occurs in hydraulic turbines has occurred in centrifugal pumps, in high pressure reservoir outlets, in steamship propellers (although this fact has not been generally recognized) and in many other special locations. Some evidence now available indicates that even the corrosion of steam turbine blading in the intermediate and low pressure stages may be due, in part at least, to the same forces that are at work in the case of hydraulic turbine runner pitting. It is felt that greater progress in the study of corrosion of metals will be made when all of these experiences are correlated instead of being considered separately.

What Length Belt Conveyors?

BETWEEN head and tail pulleys of a single belt conveyor, what is the practicable limit of distance? C. H. Adamson says, in The Labor Saver, that a mile seems a great distance, yet it is not outside the realm of possibility, and there are no fundamental reasons why this length cannot be realized.

Probably the one limiting phase of the problem which would first restrict such an extreme center is the working stress of the conveyor belt. Recent important accomplishments in long distance transportation by conveyor have developed new power economy factors; the reduction of frictional resistance in drive, idler and take-up mechanism and in the carriers has lowered the belt stresses with a corresponding increase in allowable conveyor lengths.

In nearly every belt conveyor installation the conveyor belt itself represents from 30 to 50 per cent of the cost of the installation. Long belt conveyors require high tensile strength with corresponding higher cost per foot of length of the conveyor belt. The rate of depreciation of the belt is faster than that of the machinery, therefore any conditions which increase the belt life, as for instance, ball bearing carriers, are important in lowering the unit cost per ton of material handled.

It is, therefore, the deduction that single belt conveyor installations will rarely be made in greater lengths than is standard practice at the present time. Long distance belt conveyor transportation will develop along multiple unit lines.

Pipe Welding Proves Economical

FOR PIPE 1-IN. TO 30-IN. AND FOR ALL USES. PROCESS FOR ELBOWS AND TEES. MATERIALS WHICH WORK BEST. BY H. A. WOODWORTH

IN LONG LINES of piping the weakest link has been the connecting point between the various units of pipe. To connect these units so as to give the greatest efficiency yet make the connections at a practical cost has been the puzzle that man has tried to solve since the days of Noah. Until the advent of welding the missing link of the human race was as easy to solve as the efficient piping connection. But the solution is now at hand as we have tried and proved; welding of pipe lines is the most efficient as well as the most economical method known today.

FIG. 1. ELBOWS AND TEES ARE EASILY MADE BY WELDING

In 1909 the writer made installations in Indianapolis, Ind., using welded pipe for underground and interior piping. These lines have been in service 15 yr. without giving any trouble. They carry pressures from 1 lb. to 200 lb. Today we find pressure of 300 and 400 lb. are common with welded steam pipes.

No data on actual tests of various types of welds seemed available hence it was necessary to do considerable research work. Piping materials, valves and gaskets for high pressures and temperatures are lagging far behind the requirements hence it is difficult to find materials best suited and it is necessary to make your own investigations.

Two materials that are principally used for piping work are steel and wrought iron. Of the two classes of steel, bessemer and open hearth, the open hearth is preferable, as it has less carbon and the more uniform quality. For Van Stone joint work, wrought iron pipe may split not only at the weld but all around its outer circumference. On the other hand, wrought iron pipe threads better while open hearth steel is more difficult to work.

EXPANSION JOINTS

Welding connections are less ductile than the pipe itself, hence, in making pipe bends, care must be used to keep the weld outside the bend. Several pipe bend makers have used the quarter bend, U-bend, combination U and quarter bend and the double expansion bend, steel and wrought iron being best adapted for this purpose. The slip expansion joint is far more satisfactory for expansion movement of pipe lines carrying high pressures and superheat, while for low-pressure, moist steam the corrugated reinforced expansion joint is suitable. The writer tested out various bends as compared with expansion joints and found the expansion joints more practical and efficient.

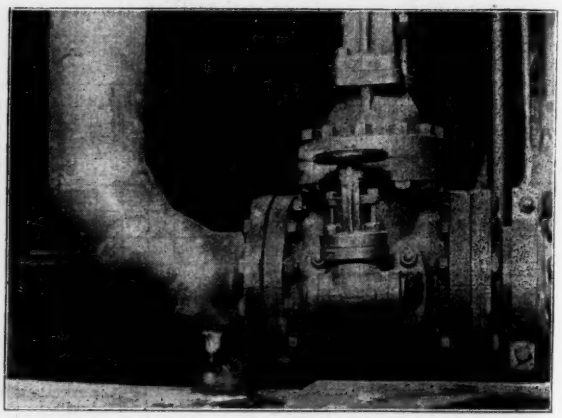


FIG. 2. SPECIAL FLANGE ELBOW AND DRIP NIPPLE SAVED EXPENSE AND DELAY

MATERIALS AND WELDING PROPERTIES

Brass and bronze are not satisfaetory at temperatures above 600 deg. as the breaking strength of bronze ordinarily used is only about 12,000 lb. per. sq. in. Cast iron is used for fittings in many power plants and in locomotives at temperatures as high as 700 deg. for superheaters. The writer has found by experiment that cast iron is never safe with superheat; even at 300 deg. and 10 deg. superheat there is danger of the metal expanding and never returning to its original shape, in time stretching to effect a permanent increase. Ferrosteel is a high grade cast iron, hence, is not to be depended on any more than cast iron. On account of the undesirability of brass, bronze, and cast iron, this article will be confined to steel and wrought iron.

The writer has supervised the welding of 100,000 ft. of steel and wrought iron pipe from 1-in. to 30-in. pipe sizes, making over 15,000 welds for power plant headers, and in underground piping for steam and hot water, city water, gas, ammonia and condensers. All welds have proved satisfactory, though, in order to find out

why some welds fail, some welds have been made that were expected to fail, in order to study the method of finding the true neutral flame to use for welding pipe.

Study of steel pipe welding resulted in finding that steel has a high melting point and is difficult to weld. The rapid solidification and the great change in structure and physical properties of the metal at the high temperature to which it is subjected during the welding process and the fact that the weld is only a casting

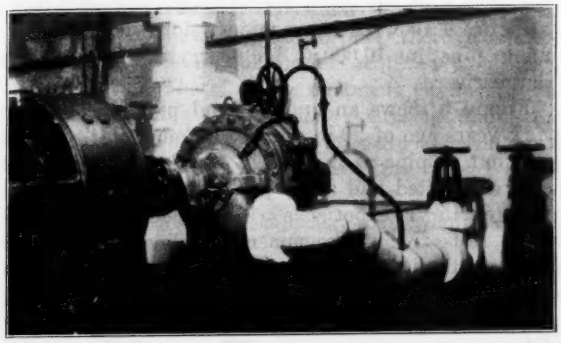


FIG. 3. -WELDED BENDS IN PLACE OF SPECIAL FITTINGS AVOIDED SHUTDOWN OF PUMP

and is therefore less ductile than the metal itself makes it imperative that the weld be made efficiently. The more sulphur in the steel, the less ductile the metal, hence, the harder and more brittle the weld. For ammonia pipe work it is important that the steel be low in sulphur, for, if sulphur exceeds 0.5 of 1 per cent, it is liable to cause porous welds. Open hearth steel pipe is best on this account and for condenser

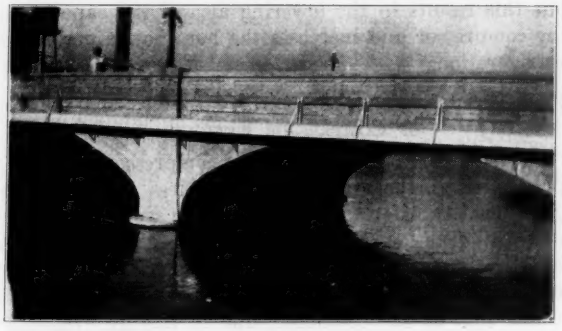


FIG. 4. 10,000 FT. IN A SINGLE STRETCH TO CROSS A RIVER, MADE BY WELDING

coils double strength open hearth pipe is best. The best and most dependable welds are those which are heat treated.

What kind of welding rod to use is worthy of consideration as the writer found that this makes considerable difference in the efficiency of the weld. After trying all kinds of rods, from bailing wire to nickel steel, the welds were tested and tensile strengths of from 30,000 to 69,000 lb. per sq. in. were obtained. For pipe lines exposed to moisture, as where pipe is installed out doors such as condensers on the roof of a plant, the nickel steel rod was found less liable to corrosion. Poor grades of welding rods such as bailing wire rust rapidly, in some cases as much as four per cent in a year.

Preparation for Welding

In preparing pipe for welding, the writer found it gave best results to scarf the pipe in the machine, 45 deg. scarf being the best. For welding heads in pipes, separators, and ammonia receivers, also for bumped heads, a butt weld can best be made by using 45-deg. scarfs.

In making reducers, the larger pipe is belled out, the smaller pipe then inserted and welded. It is necessary to make a wide weld on this fitting in order to get the desired thickness of the metal at the center. Ninety degree elbows are simple to make using two 45-

FIG. 5. THIS MASS OF 20-IN. FITTINGS COULD BE REPLACED BY A WELDED CONSTRUCTION AT HALF THE FIRST COST

deg. welds as in Fig. 1. The length of the center piece on the inside is equal to one half the diameter of the pipe so that all elbows are of uniform size. Tees are made by first cutting the nipple to a saddle form to fit the pipe, the nipple then serving as a pattern for marking off the hole. After cutting the hole it is scarfed to 45 deg. on the side and back about two times the thickness of the metal on top of the pipe. Patterns are used for laying out tees and elbows so that a perfect fit is obtained without trimming.

Figure 1 shows a welding job where an 8-in. tee and 8-in. special angle are made by the oxy-acetylene process. Figure 2 shows a welded 8-in. flange, elbow and drip trap nipple connection, with a saving of fittings and expense as well as delay waiting for such specials.

The writer has tested the time element for various kinds of welds and found that the average practice and costs for straight welding, fittings made of pipe, labor,

gas, etc., can best be figured from the accompanying table prepared by Charroin Welding Company of St. Louis in June, 1924:

ESTIMATED COST OF WELDING EXTRA HEAVY PIPE

Pipe Size in.	Time min.	Oxygen cu. ft.	Acetylene cu. ft.	Overhead per cent	Cost
3	30	8½	8	20	$ 1.34
4	40	12½	11	20	1.82
6	60	28	23	20	3.12
8	80	35	29	20	4.03
12	110	67	56	20	6.45
16	150	112	93	20	9.86
20	210	150	125	20	14.70

Add 10 per cent for setting up straight line welds.

Add 25 per cent for setting up tees, crosses and headers.

Add 15 per cent on 45-deg. miter welds.

Add 10 per cent on all 30-deg. miter welds.

Add 20 per cent for cutting.

Add 30 per cent for extra time and gas on all stationary welds.

Deduct 20 per cent for standard pipe.

Add 10 per cent for cutting standard pipe.

These figures are estimated on the following rates: labor, $1.50 per hr.; oxygen, $.01½ per cu. ft.; acetylene, $.03 per cu. ft.

Figure 3 shows the application of welding to a large boiler feed-water pump for which special fittings were impossible to obtain and where the welding made it possible to keep the plant operating without shut down.

Figure 4 shows a steam main welded making a continuous pipe line 10,000 ft. long carrying the line across a large river.

Figure 5 shows an underground pipe line installed a few years ago of 20-in. fittings. Today this would be made out of pipe as in Figs. 1 and 2, all gasket joints being eliminated and at 50 per cent the former cost.

After 15 yr. experience with welded pipe lines, the writer feels free to recommend welding and has tests to prove that the welded joint is more efficient and stronger than the pipe line material itself.

Preventing Ammonia Compressor Troubles

DISCUSSION OF FACTORS THAT MAY REDUCE EFFICIENCY OF COMPRESSOR, SUCH AS INCORRECT PRESSURES, NON-CONDENSABLE GASES AND POOR HEAT TRANSFER IN SYSTEM. BY H. J. MACINTIRE

UNLIKE SOME MACHINES in the power plant, the refrigerating compressor must be operated in a particular manner, otherwise poor or even no useful results will be obtained. The suction pressure must not be too high or the proper temperature will not be obtained; if the suction pressure is too low the capacity will drop off very sharply. Both of these poor results are the result of an improper adjustment of the expansion valve. If the condenser is out of order or the water on the condenser is insufficient in amount or has not a low enough temperature, the condenser pressure will become excessive and serious trouble will develop.

The expansion valve is the pressure regulating valve separating the high pressure (the condenser) side of the system from the low pressure (the evaporating) side. Its function is to control the amount of liquid entering the refrigerating coils so that the proper pressure, and therefore the proper temperature, will be maintained in the low pressure side. If the load is constant and the compressor is operating at a constant speed, conditions will automatically adjust themselves after a time with any setting of the expansion valve, and the suction pressure will raise or lower until the weight of ammonia being drawn into the compressor and condensed in the condenser is equal to the amount passing through the expansion valve.

Every plant, however, has its own proper operating pressure, dependent on the work being performed, such as ice making, cold storage work or cooling air in process work or in a building. This is such an operating pressure as will give 3, 5, or 10 or more degrees difference in temperature between the evaporating temperature of the refrigerant and the temperature of the fluid surrounding the evaporating surfaces. The low pressure piping is laid out with the idea in view of having this particular difference of temperature, so that each plant —to do its particular duty—must be operated according to the conditions for which the plant was designed. Incidentally, it is the generally accepted statement that the cheapest part of the refrigerating plant is the piping and that a liberal amount of piping results in the greatest economy. With a certain amount of evaporator surface, provided it is clean and operated in the correct manner, if the desired temperature cannot be secured the only alternative is to decrease the suction pressure, but this results in the lowering also of the capacity of the compressor and increases the horsepower per ton of refrigeration.

POOR HEAT TRANSFER IN SYSTEM MAY CAUSE REDUCTION OF COMPRESSOR EFFICIENCY

During the operation of the compressor there is a possibility of the system becoming less efficient as regards heat transfer. The refrigerating system is a closed one, using the same refrigerant over and over but it is subject to troubles inherent in the manner of operation. Scum, dirt and scale may accumulate on the water side of the condenser due to impure evaporator surfaces; leaky valves, piston rings or scored cylinder walls may result in poor pumping in the cylinder; obstructed circulation of the water or the ammonia may put the condenser out of commission or at least decrease its working ability; and faulty action in the brine cooler or the direct expansion piping may result in a poor heat transfer.

How these factors may affect the capacity and operation can be shown by the following actual case. Removal of a large accumulation of ice and frost permitted the evaporating pressure, in a certain set of ammonia direct expansion piping to be raised from 3.0 to 15 lb. gage with an equally good resulting room temperature. Removal of a long accumulation of oil in the pipes permitted further increase in the suction pressure to the machine from 15 to 17 lb. gage.

The piping was now working efficiently and as well as it was when erected. This particular set of coils, however, was under-piped and, by increasing the piping, the same desired temperature of the room was obtained by operating at 22 lb. gage. Referring to the curves for capacity of ammonia compressors, it will be seen that a compressor, under 150 lb. condenser pressure, will require 9.2 cu. ft. per min. piston displacement per ton of refrigeration at 3 lb. gage and 3.7 cu. ft. at 22 lb. gage. Under these conditions the same compressor would deliver nearly 2.5 times the capacity at 22 lb. as at 3 lb. suction pressure, and there would be but little increase in the power required to operate the compressor. Therefore the operating engineer needs to keep his refrigerating system operating under the best conditions and the suction pressure at as high an amount as is possible for the temperature being secured in the cooler.

Loss of refrigerating capacity in a plant may be caused by:

a. Insufficient piping surface, or frost on the outside and oil and scale on the inside of the evaporator piping.

b. Leaky valves, or leaky safety head, piston rings or scored cylinders in the compressor; slow closing of the valves due to a number of causes.

c. Obstructions in the suction lines or broken valves preventing full opening of the valve.

d. Too small a charge of ammonia, thereby permitting uncondensed gas to pass through the expansion valve (and thus choke the evaporating coils) due to a lack of liquid seal on the valve.

e. The presence of water in the evaporating coils which results in the necessary lowering of the operating pressure in order that the same temperature of evaporation may be carried in the coils. Water may accumulate in the refrigerating coils in a number of ways, but mostly by carelessness.

Causes of Excess Pressure

Condenser pressure depends on the temperature and the amount of condenser water showered over the condenser. For an efficient condenser, without air present, the pressure corresponds closely to the pressure at saturation for the temperature of the water leaving the condenser. Excess pressure may be caused by:

1. Too small a condenser, hot cooling water or too small an amount of water for the load carried and the temperature of the water used.

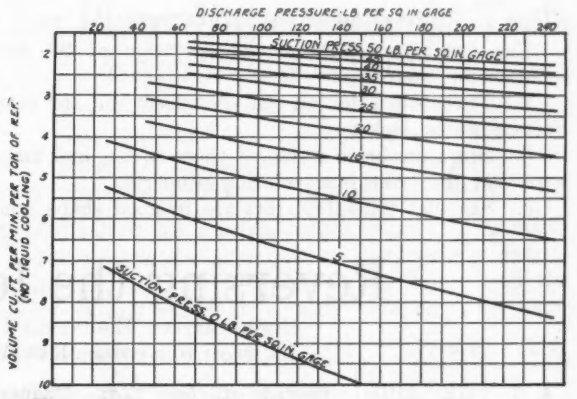
2. Inert gases in the condenser and the liquid receiver caused by decomposed lubricating oil to some slight extent, but for the most part to air.

3. Poor heat transfer, due to dirt and scale in the cooling water which accumulates on the water side of the condenser; oil, scale and dirt which settles on the ammonia side of the condenser.

4. Decrease of effectiveness of the condenser surface due to the accumulation of liquid in the condenser, possibly due to an overcharge of ammonia for the suction pressure being carried in the plant.

5. One or more stands of the condenser not carrying their proportionate load due to a broken valve or other difficulty, in consequence of which the liquid cannot drain out properly.

In charging a new plant it is the custom to pump a vacuum on the entire system in order to remove as much as possible the air present in the piping. Even with a good vacuum there will be an appreciable amount of air remaining; this, in the natural course of events, will finally accumulate in the condenser where it will remain until it is removed by the action of purging. After operation begins, if no repairs are made in the system, there is no real cause for further accumulation of air if the operating engineer will use care in the control of the plant, as it is evident that air cannot enter the system very well without having a pressure in the evaporating coils lower than that of the atmosphere. A vacuum in the system is not necessary except in unusual cases, for even sharp freezers requiring —20 deg. F. can secure this temperature in the evaporating coils without a vacuum. If the operator carries a vacuum, however, air will certainly work into the cylinder through the stuffing box of the piston rod. That ammonia will not disintegrate under usual operating pressures and temperatures is evident from the experience of careful engineers who do not have to purge the condenser during the entire season.


DISCHARGE PRESSURE-LB PER SQ IN GAGE
20 40 60 80 100 120 140 160 180 200 220 240
SUCTION PRESS. SQ LB PER SQ IN GAGE
VOLUME CU FT PER MIN PER TON OF REF. (NO LIQUID COOLING)
2 3 4 5 6 7 8 9 10
40
35
30
25
20
15
10
5
SUCTION PRESS. 0 LB PER SQ IN GAGE

CURVES SHOW CAPACITY OF COMPRESSORS FOR VARIOUS SUCTION AND DISCHARGE PRESSURES

The action of air in the condenser is to increase the pressure indicated by the condenser gage. This gage indicates the total pressure, which is that exerted by the ammonia plus that due to the air present. The pressure of the air is that amount which it would itself exert if occupying the condenser volume by itself and at the same temperature. The pressure exerted by the ammonia is that surface tension occasioned by the ammonia during liquefaction and (if the ammonia is pure) it is the pressure corresponding to the temperature of liquefaction. The law of partial pressures is then P [total] = p_1 [of the air] + p_2 [of the ammonia]. The gas in the condenser is a mixture of a non-condensable gas and a vapor, in different percentages in different parts of the condenser. If the air is present, the substance surrounding the condenser surfaces is nearly pure air while the condenser is in operation. The mixture having the larger proportion of air is where the cooling water is the coldest, but a non-condensable gas is naturally swept along in the direction of the flow of the ammonia. Purging to free the condenser of foreign gases should be at the point of maximum density. This would be the upper part of the

shell-and-tube condenser and the bleeder condenser, but it is the lower part of the double pipe and the common atmospheric condenser, or the liquid receiver.

Purging should be given considerable care as without question a large amount of unnecessary purging is carried on and under no circumstance, whether a purging device is used or not, is it possible in practice to purge without losing ammonia. The easiest manner to purge and yet to conserve the ammonia is to "freeze" the ammonia out of the mixture by the action of refrigerating coils, made up either as a shell and coil or as a double pipe arrangement. All that is required is to cool the mixture as low in temperature as is practical, under which conditions the partial pressure of the ammonia will be reduced and the weight of the ammonia in the mixture per cu. ft. will be reduced in proportion to the density of the ammonia at that temperature. This method will not free the gas being purged out of the system of all the ammonia, hence it is best to free the system of air and not to permit any further accumulation to take place by careless operation or by the unnecessary opening of the ammonia pipe lines for repair.

Starting up the Compressor

The usual procedure in the operation of the ammonia compressor is as follows:

a. Turn the water on the condenser and the compressor water jackets.

b. Start the brine pump, if there is one, and make sure that the brine is circulating properly.

c. See that the lubricators are in good shape, and see that oil is flowing properly. Give the ammonia cylinders a small amount of the proper cylinder oil for ammonia.

d. See that the suction and the discharge valves on the compressor are closed and open the bypass from the discharge to the suction line.

e. Start the compressor and

f. Open the suction and the discharge valves. Close the bypass valve.

g. Adjust the expansion valve so as to get proper operating conditions. (See that a vacuum is *not* pumped on the system during the interval of starting up and while the expansion valve is closed.)

h. See that the condenser is functioning properly by feeling of the connections and that there is a proper liquid seal on the expansion valve. Check the condenser pressure with the temperature of the water leaving the condenser.

i. Note the temperature of the gas returning to the compressor and see whether it is not possible to control the temperature to within 10 to 20 deg. of the evaporating temperature. Note the discharge temperature and see whether this cannot be maintained over 200 deg.

In conclusion, try to keep the plant in A-1 condition with the surfaces operating in the manner they were designed for. Keep air and oil out of the system. Keep the evaporating surfaces free of excess dirt and frostation. Have the condenser pressure as low, and the suction pressure as high, as possible with economy. Investigate anything unusual and remedy any defect at the earliest opportunity.

Reversing the Ice Making Process

Refrigerating Engineers Discuss Feasibility of Making Ice from Sub-cooled Raw Water.* By Charles H. Herter

AT THE APRIL meeting of New York Chapter No. 2, N. A. P. R. E., Halbert P. Hill, of Ophuls & Hill, consulting engineers, New York, gave an interesting talk on new methods of freezing water. Mr. Hill spoke about as follows: Gentlemen—Let me give you some food for thought. Let me show you that there are things so common to us that we never give them a thought. Take as an example ordinary ice. You say it is simply water congealed to ice at 32 deg. So it is, but did you know that under certain favorable conditions its freezing point can be depressed as much as 10 deg. below 32 deg. F.? To do so the refrigerating medium must be not more than two degrees below the temperature of the water, otherwise ice crystals appear suddenly and the whole mass will soon become slush ice, opaque. The ice crystals do not group themselves as regularly as in the ordinary process of making ice and, as each crystal seems to be covered with a thin film of water, the ice has an opaque appearance.

A method remains to be found for overcoming this disadvantage. Experiments have been made with double pipe coolers, the freezing water flowing through the 2-in. pipe and the ammonia vapor passing through the 3-in. pipe, the evaporating temperature being successively and cautiously reduced from about 34 deg. to 28 deg. (43 lb. gage pressure). If a piece of ice is dropped into water sub-cooled to 31 deg. F., 1/144 of that water will flash to ice and the temperature will jump to 32 deg. The ice needles obtained are exceedingly small and of themselves they do not unite into a solid mass. If air agitation is used, snow balls result. These can be compressed into a solid cake. Operating thus with half ice and half water, the freezing time is 66 per cent shorter than if starting with plain water.

Problem Still Far from Solution

As yet the method of making ice with subcooled water is not commercially successful, but it is probable that in due course the process will be perfected. To get the water down to 20 deg. F. an exceedingly smooth glass surface is necessary; a surface of aluminum is too coarse and the surface of ordinary tubing or pipe is entirely too rough for this purpose, as it invariably causes flashing into ice within the cooler, so that the process must be interrupted. In the course of their experiments Ophuls & Hill have had pipe flashed and enameled under heat, the same as kitchenware.

You wonder why with air at 10 deg. outdoors the water in the brook does not all freeze up solid. According to the statements of physicists, water when lowered to 32 deg. F. freezes to ice. The reason for this

*For further details of what has been done in this field, the reader is referred to a paper by H. P. Hill on "Methods of Freezing Raw Water," published in Refrigerating Engineering, October, 1922.

condition is that, for each pound of ice formed, 144 heat units must be removed; this is the latent heat of fusion. It takes time to do this. The velocity of the stream may be greater than that of crystal formation.

Where does water come from? From the atmosphere. Evaporation of water results in ice making, as is demonstrated by the vacuum ice machine. Coming back to the stream, the earth's ground temperature is about 50 deg., immediately above that in the bed of the stream is water at 39 deg. F., the temperature of maximum density. The 32 deg. water is lighter per cu. ft. and therefore floats on the surface, consequently ice is formed only at the surface, and the cold air has to draw the heat from the water film under the ice, thus building up ice at the water side.

Theory Indicates Power Saving

Charles H. Herter asked Mr. Hill to explain his object in experimenting with subcooled water. The answer was, increased economy in the cost of making ice. Mr. Hill related how refrigerating engineers have endeavored in the past 35 yr. to cut down the cost of making ice. He spoke of the moderate economy obtained with simple engine steam plants making distilled water ice; then compound engines were used, then surface steam condensers, then evaporating apparatus. Now we make ice from raw water, use uniflow steam engines or oil engines, or electric drive where current is available at favorable rates. The next step, he figures, should be in the direction of improving the ammonia evaporating side of the system by operating at high suction pressure. If, by the use of sub-cooled water, the suction pressure can be kept at 43 lb. instead of 20 or 25 lb., the capacity of the compressor and its power per ton of ice will be affected favorably, therefore the cost should be materially lower. It was true that ice from subcooled water was not transparent, nevertheless it was fully as pure as the water from which it is made. In due time it may be possible to educate the public to the merits of pure white ice, although now the more expensive clear ice is the custom, people still associating purity with transparency.

Practical Difficulties of New Process

Charles H. Herter supplemented Mr. Hill's remarks by stating that in his opinion subcooled water ice was commercially not feasible for the following additional reasons. It has been found extremely difficult to prevent ice formation where the lowest temperature in the systems prevails, namely within the water coolers, because the temperature difference between subcooled water and ammonia should not exceed 2 deg. F. This range is too narrow for successful continued operation. Water coolers with especially smooth surfaces inside will be costly because of the very small temperature difference used, which necessitates enormous cooling surface and with it radiation is lower. The pump work will be excessively high because, to remove one unit of latent heat per pound on the average in each round trip through the ice mould required 144 round trips before the 144 B.t.u. per pound are abstracted. This excessive pump work is to be deducted from the power saving made at the ammonia compressor.

Incidentally, this saving is not so great where the water and liquid ammonia are being forecooled anyway at 43-lb. back pressure and where the freezing tank coils are being operated at 25 to 30 lb. back pressure. At 30 and 165 lb. gage the brake horsepower of a refrigerating machine per ton ice is 1.7, while at 43 and 165 lb. gage pressure it is 1.32, or but 77.6 per cent of the former. On the whole the subcooled water ice appears to promise no larger power saving than 20 per cent over a well designed standard plant, and this fact coupled with the many other serious difficulties enumerated above does not seem to warrant the necessary expenditure.

If one insists on better performance, two-stage compressors can be employed, the condenser pressure can be cut down and many economies effected in design and operation without risking the interruptions in manufacture that are to be anticipated with the opaque subcooled water ice. It will be of interest to add that methods of making ice with subcooled water are covered by U. S. patents No. 659,554 and 659,610, issued Oct. 9, 1900, to Thomas Shipley, of York, Pa., and by U. S. patent No. 1,195,495 granted August 22, 1916, to Fred Ophuls, New York.

Ice Plant Improvements Test Engineer's Ability*

By Correcting Load Distribution, an Engineer Showed His Knowledge of Principles of Refrigeration and Prevented Operating Trouble. By H. G. Venemann

YOUR JOB AS a refrigerating engineer is to manifest skill in the principles and practices of refrigerating engineering. Your first duty is to keep the machinery and equipment already installed in the highest state of physical perfection. This is largely a matter of mechanical ability. Your second duty is to produce the best results with that equipment on the least expenditure of money. This requires energy, intelligence, executive ability, and an abundance of common "horse-sense." A third and most important part of your job is to conceive and devise plans for improvements and extensions in the plant, and to see that they are put into effect. An engineer may be ever so skillful in perform-

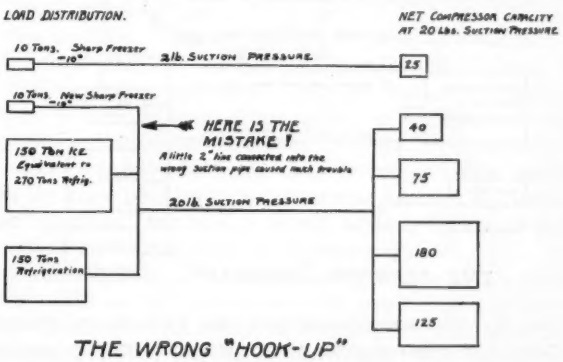

LOAD DISTRIBUTION.
NET COMPRESSOR CAPACITY AT 20 LBS. SUCTION PRESSURE.
10 Tons. Sharp Freezer -10°
2 lb. SUCTION PRESSURE.
15
10 Tons. New Sharp Freezer -18°
HERE IS THE MISTAKE!
A little 2" line connected into the wrong suction pipe caused much trouble
150 Tons Ice. Equivalent to 270 Tons Refrig.
20 lb. SUCTION PRESSURE
40
75
180
150 Tons Refrigeration
125
THE WRONG "HOOK-UP"

FIG. 1. LOAD DISTRIBUTION OF COMPRESSORS BEFORE CORRECTING, SHOWING NEW SHARP FREEZER CONNECTED TO WRONG SUCTION LINE

*Abstract of paper presented at N. A. P. R. E. Convention.

ing the first two duties, but his success will often be measured by his ability to make improvements.

As an instance of this, the following account shows how a new engineer in a certain plant, by applying his scientific knowledge to existing conditions, corrected a bad mistake that had been made by his predecessor, an old engineer with practically no technical knowledge. In this plant four compressors, with a combined refrigeration capacity slightly in excess of 420 t., had been working together on the high temperature duty, including ice-making, creamery work, and all rooms of 20 deg. temperature and over. The suction pressure had been running about 20 lb., and the discharge 185.

Original Connections of New Sharp Freezer Prove Incorrect

A fifth compressor of about 25 t. capacity had been working independently on the sharp freezer load at two pounds suction pressure, as shown diagrammatically in Fig. 1. A new sharp freezer had been built just prior to the change in chief enginers and, realizing that the 25-t. machine was inadequate to take care of any additional load, this new sharp freezer had been heavily piped and connected into the high pressure suction line, Fig. 1. The new chief engineer was given instructions by the general manager of the company to maintain a temperature in this room of 5 deg. below zero. He immediately notified the manager that to attempt such a thing would cost the company hundreds of dollars each day, by reducing the daily ice output from 150 t. to less than 40.

This was the new chief's first conflict with the management. They could not understand why the addition

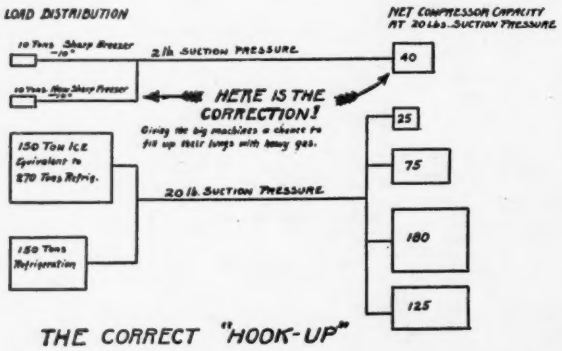

LOAD DISTRIBUTION
NET COMPRESSOR CAPACITY AT 20 LBS. SUCTION PRESSURE
10 Tons Sharp Freezer —10°
10 Tons New Sharp Freezer —5°
2 lb. SUCTION PRESSURE
HERE IS THE CORRECTION!
Giving the big machines a chance to fill up their lungs with heavy gas.
150 Ton Ice Equivalent to 270 Tons Refrig.
150 Tons Refrigeration
20 lb. SUCTION PRESSURE
40
25
75
180
125
THE CORRECT "HOOK-UP"

FIG. 2. BY CROSS-CONNECTING THE NEW SHARP FREEZER LOAD AND COMPRESSORS AS SHOWN, THE NEW LOAD WAS CARRIED WITH PRACTICALLY NO LOSS

of a 10-t. sharp freezer load could possibly cause them to lose over 100 t. of ice a day. The suggestion, to their minds, was preposterous, unreasonable, almost insane.

The new chief informed them that the "hook-up" was wrong, and ordered fittings to enable him to make connections into the 5-in. low pressure suction line. In the meantime he proceeded to demonstrate his theory. He reduced the suction pressure from 20 to 15 lb. and dropped the freezer room temperature to 15 deg. F. Had it not been piped exceptionally heavy, it probably would not have been colder than 22 deg. F. This reduction of suction pressure was effected by cutting down the expansion valves on the ice freezing tanks, for the compressors did not have sufficient surplus capacity to enable them to keep it lower than 20 lb. normally, and they were already operating at safe maximum speeds.

This reduction in pressure of only 5 lb. reduced the refrigeration tonnage from 420 to 352, and since the cold storage load had to be maintained, the ice tanks had to absorb the total loss, resulting in decreasing the ice output 38 t. per day, from 150 t. to 112. See Table.

DECREASE IN SUCTION PRESSURE CAUSES DECREASE IN PLANT CAPACITY

Suction Pres. (Gauge)	Suction Temp., Fahr.	Room Temp., Fahr.	Theoretical Displacement cu. in. per ton per min.	Volumetric Efficiency at 185 lb. discharge	Actual Displacement cu. in. per ton per min.	Per cent capacity with 20 lb. suction as 100%	Normal Tonnage of 4 Compressors	Fixed Cold Storage Load. Tons Refrig.	Bal. Available for Ice Making	Tons Ice Made	Tons Ice Loss per 24 hours
20	+ 6.1	+22.	5904	80	7380	100.	420	150	270	150	None
15	— 0.3	+15.	6864	78	8800	83.8	352	150	202	112	38
12	— 7.7	+ 7.	7605	76	10000	73.8	310	150	160	89	61
8	—11.0	+ 3.	8895	74	12000	61.5	258	150	108	60	90
5	—16.5	— 3.	10212	72	14200	52.0	218	150	68	38	112
2	—22.6	—10.0	11960	70	17100	43.1	181	150	31	17	133

Instead of following orders, the engineer cut into the 5-in. low pressure suction line with this new freezer; by means of bypass valves, he shifted the 40-t. compressor onto the low temperature work, changed the 25-t. machine onto the high temperature work, and secured the desired results, without losing more than 8 t. of ice a day. Figure 2 shows the changes effected. This new chief knew the properties of ammonia and applied his knowledge scientifically.

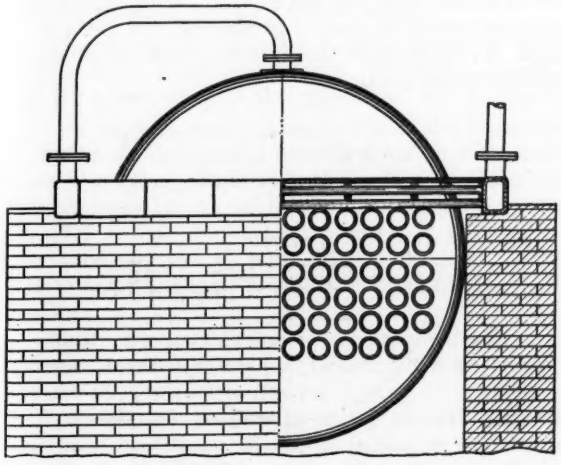
Commonwealth Edison Co. Receives Coffin Award

NINETY-FOUR PER CENT of all homes in Chicago, the second largest city in America, now use electricity. This achievement in a city of 3,000,000 population was one of the outstanding accomplishments of the Commonwealth Edison Co. during the past year and one of the reasons for which it was awarded the Charles A. Coffin Foundation gold medal. Presentation of this medal was made on the evening of May 19 to Samuel Insull, president of the Commonwealth Edison Company, by J. E. Davidson, president of the N. E. L. A. before several thousand delegates attending the annual N. E. L. A. convention at Atlantic City. With the medal and certificate of award, a check for $1000 was presented to Mr. Insull to be given to his company's employes benefit association. For the year 1925 the amount of energy sold by the Commonwealth Edison Co. reached the imposing total of 2¾ billion kw-hr., a gain of 12.8 per cent. Much of this gain may be attributed to the success which attended unusual efforts to popularize and introduce domestic appliances, and to campaigns for better lighting. Of the 720,000 homes in the city, 679,500 now use electricity and the average consumption per resident customer for the year was 494 kw-hr.

Accidents are somebody's fault; don't let them be yours, urges A. L. Watson of the National Safety Council.

Superheaters for H. R. T. Boilers

EXPERIENCE shows that superheaters can be added to horizontal return tubular boilers at small cost and, in most cases, with marked improvement in operation. The fuel bill is considerably reduced wherever superheat is used, cases being on record where 100 deg. of superheat in small industrial plants has shown economies of 20 per cent, whereas the average plant will



INSTALLED AT THE REAR OF AN H. R. T. BOILER, THE SUPERHEATER TOGETHER WITH ITS CAST-IRON COVER PLATES, TAKES THE PLACE OF A REAR ARCH BESIDES SUPPLYING SUPERHEATED STEAM

show anywhere from 8 to 15 per cent. Many boiler rooms are heavily overloaded, due to insufficient capacity and, with superheaters added, the increased capacity is enough to relieve this overload condition and enable the equipment to be operated efficiently and with much lower maintenance costs.

In small plants, invariably there is considerable trouble due to the moisture in the high pressure steam lines and the elimination of this gives noticeable improvement in economy. Steam traps are not compelled to function so frequently, reciprocating machinery performs much better and the danger of slugs of water upon this class of equipment is almost eliminated, making the plant much safer and tending to produce better operating results. Elimination of moisture or condensate in steam cylinder makes lubrication easier as moisture or water has a tendency to wash the cylinder walls, removing lubrication, whereas it can be better distributed in a dry cylinder.

Apropos of the article in the March 15 issue, p. 389, the accompanying figure shows a superheater which has been designed especially for horizontal return boilers with special stress laid on mechanical accessibility, ease of installation and first cost. This superheater is located at the rear of the boiler but above the tubes, thereby replacing the rear arch. It is so located that the rear tube sheet is entirely accessible for cleaning, maintenance or repair.

Utilizing a superheater of this type requires no great alteration or expensive charges, even on existing installations. Operation is dependable, giving a uniform degree of superheat which never exceeds 100 deg. and usually is between 80 to 90 deg. where coal or oil is used as a fuel. With natural gas the temperature is approximately 10 per cent lower. These figures are based on steam having a moisture content of 1.5 to 2 per cent.

Kansas City, Mo. L. J. MART.

What the Engineering Salesman Can Bring

YOUR EDITORIAL in the April 1 issue, under the above title, may be true of a few salesmen, but the majority are just a poor, tired, overworked crowd like the rest of us. I have been a salesman and an engineer and although manufacturers do a great deal to train their men and see that they know what they are selling, I find that the men are often narrow and prejudiced in their views and opinions. They are rushed keeping up their volume of sales, often traveling at night and not overly well informed of current engineering progress.

In fact, after knowing them from the inside, one is in the same position as a doctor who gets sick and needs an operation, but who is afraid because he knows that doctors are human and not supernatural.

Although the salesman is useful, it is only in a small way. He can help sometimes with small details or point out features which might be overlooked. One must not forget, however, that he is out to sell. His income depends on that and that is what he has on his mind all the time. By hearing them all you get every possible angle, but it is necessary to remember that a good high-powered salesman will show you 40 sides on a common, ordinary shoe box, and the funny part of it is all 40 sides are in plain view from his one angle.

The next man shows you 40 other sides and, when you sit down by yourself and analyze them, you find that in effect, instead of looking at the shoe box, you were looking in one of the trick mirrors found in penny arcades.

Young technical men do not have the practical training to be of real service. They can't get it in a year, or two years puttering around a factory, while the old practical men are not technical and although they can

make the wheels go round they are of use only to the operating engineer.

I will not deny that there are a lot of good engineers who are salesmen and many salesmen are good engineers, but they do not come in touch with the ordinary run of engineers and are of little value to the majority. They do not remain long as salesmen either.

Any power plant engineer who uses his own head in going over published trade and technical literature is much better off than the fellow who depends upon some salesman to give him the information secondhand.

Bronxville, N. Y. B. MARKER.

Handy Acid Vat for Small Parts

IN FIG. 1 is illustrated a handy and inexpensive acid vat to contain muriatic acid for cleaning small parts and fittings. The container is half of an oil or paint

FIG. 1. BY USING HALF OF AN OLD OIL BARREL AND SUPPLYING A SHEET-IRON COVER, A HANDY ACID VAT WAS MADE

barrel. As the wood is well oil soaked, it resists the action of the diluted acid for a long time and its renewal is a small item.

Details of the cover are shown in Fig. 2. It is made of ¼-in. sheet-iron, which can be cut out with the gas torch quite readily. Four lugs left in the cutting keep the cover securely over the top of the container. It sheds the rain and moisture, keeping the acid strong but at all times accessible. This home-made receptacle can be made cheaply and is quite convenient back of the plant for removing lime and water incrustations from numerous pipe fittings.

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Engineers Should Learn Salesmanship

OFTEN IT HAS been said that the most successful engineers are those who know how to sell their services, convincing the purchaser of the value of the product. He understands psychology or is sensitive to the reactions of his contacts (people he meets or works with). The engineer must learn to sell and advertise himself as the controlling factor in the cost of power production.

What do the people for whom he works know about his problems? How can he put across the ideas he has for the reduction of the cost of power and receive the recognition he deserves for so doing? There is but one way and that is to sell his ideas and advertise his product. I do not mean that he is to spend his time running around with a sample case, approach his prospect, open the sample case and sell the prospect on the sample. But I do insist that he learn the fundamental principles of salesmanship and apply them in the manner which I shall describe.

First, we must look over the product and see what we have to sell, and then the prospect, and find out what he needs, then we must build up a selling campaign, showing how the product will satisfy these needs. The product is good, he is confident (in the engine room), he is ambitious, he studies his work, he is honest, he has no time for frivolity, he can be depended upon, and he knows his plant. He knows engines, boilers and accessories, electrical work and pipe fitting, fuel and furnaces, combustion and machine shop practice, he knows how to handle men, and has some excellent ideas on how he could reduce the cost of production, not alone in the plant but throughout the factory which consumes the product of the plant.

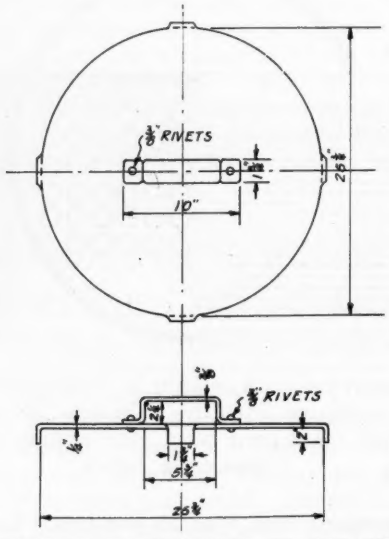


FIG. 2. DETAILED MEASUREMENTS OF THE SHEET-IRON COVER

What are some of his weak points? He cannot tell anyone but a fellow engineer about it because he talks the technique of engineering instead of business, and he does not get far enough away from engineering to see the plant from his employer's viewpoint. This is the product we have to sell to the plant owners.

What are the employer's needs? Dependable power and, in many industries, heat, at the lowest possible cost, and ideas for reducing the cost of production. There is more money paid for ideas than for the time of the routine worker; ideas are in demand and the employer is looking for them. He will want these ideas presented in a clear, concise manner and only after careful consideration of their fitting into the general scheme. Also, he insists on the handling of work with minimum supervision. These are a part of his needs.

Salesmanship for the engineer is specialty selling

which has characteristics of its own. These are a thorough knowledge of the product to be sold and its application, and it differs from staple selling in that usually the prospect is not aware of the fact that he needs the product. Therefore, in selling a specialty the need for it must be developed. The next step is proving that the product satisfies several conditions. It must so reduce the cost, improve the service or increase the sales of the company's product that the advantage of the purchase is clearly evident. Applying this to the engineer's business of selling himself and his ideas to the buyer, how shall he go about it?

First, he must know the buyer, and how best to present his own idea, by knowing his wants and his interests in order not to waste the time of both in presenting propositions entirely foreign to the company's needs, thus reducing wasted effort. In the above, we have the engineer's pre-approach. It consists of a study of the company's problems, how to solve them, and to present this solution in such a way that the need is evident, the solution positive, and the results assured.

In sales talk the first part is called the approach, its purpose being to arouse curiosity and create interest so that the presentation of the proposition will be possible.

Next, he must establish confidence in the proposition by giving the figures and backing them up with results secured in other plants and, if possible, by statements of authorities on the subject, trade magazines being a powerful source of clinching proofs. If it never has been tried out and he must develop the need, he will have to make this clear before attempting to present the solution.

Closing a sales talk has as its principal object the securing of assent to the proposition. It must be made easy for the prospect to decide.

What has this to do with selling himself? He has established confidence, displayed initiative, and an interest in furthering his employer's interests. He has sold him an idea that will reduce cost and has established a contact (mutual interest) by presenting a proposition from the employer's viewpoint.

Vermillion, So. Dak. L. A. COWLES.

Chart Gives Pulley Sizes for Rubber Belts

IN THE accompanying figure the chart tells almost instantly the proper diameter of pulley to use for any number of plies of rubber belting. It also takes into consideration any working stress ranging from 210 to 280 lb. per sq. in.

Furthermore, it simplifies the problem by giving the three most common weights of duck in Column A: 28-oz., 32-oz. and 36-oz., corresponding with 220, 237, and 252 lb. per sq. in. working stress respectively.

For example, if a given belt is made of 32-oz. duck and it is a 7-ply belt, what is the minimum pulley diameter?

Answer: Run a straight line through the point in Column A corresponding with 32-oz. duck and the 7, Column C, and the intersection with Column B gives the answer as 18 in., minimum pulley diameter.

Because of the fact that rubber belting is always made up in plies, this matter of minimum pulley diameter is important. Extremely small pulleys must be avoided if at all possible. Thus, Column B shows that no pulley smaller than 5 in. should ever be used with a standard rubber belt.

This chart is based upon the following rule: "Extract the cube root of the working stress in pounds per square inch, multiply by the number of plies and divide by 2.4. The result is the minimum diameter of the pulley in inches."

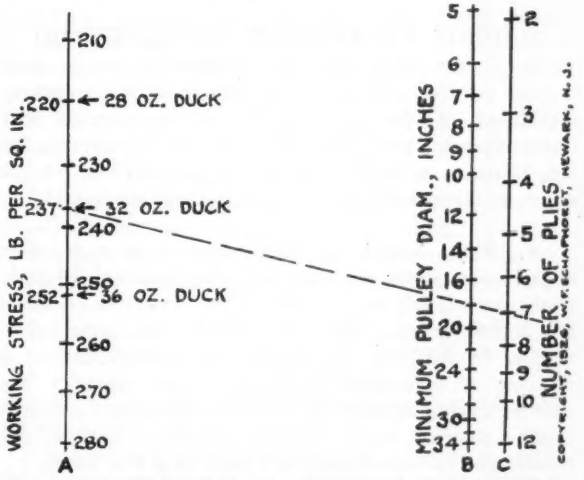


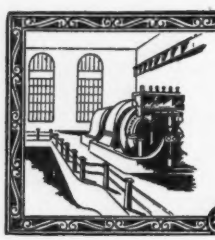
CHART SHOWING RELATION BETWEEN WORKING STRESS IN BELTING, NUMBER OF PLIES AND MINIMUM ALLOWABLE PULLEY DIAMETER

Or, vice versa, this chart may be used for determining the maximum number of plies when the working stress and the pulley diameter are known by simply running a straight line through the two known factors.

To assist in the selection of a well balanced belt so that it will be neither too thick nor too thin, the following table will prove useful. Thus, for instance, if the belt width is 10 in., it is generally considered best not to use less than four or more than six plies.

Belt Width Inches	Number of Plies, Minimum	Number of Plies, Maximum
2	2	3
3	3	4
4	3	5
5	4	5
6	4	5
8	4	6
10	4	6
12	4	6
14	5	6
16	5	6
18	5	6
20	6	7
22	6	7
24	6	7
26	7	8
30	7	8
36	8	10
42	8	10
48	8	10
54	10	12

Newark, N. J. W. F. SCHAPHORST.



QUESTIONS AND ANSWERS

Sulphur Dioxide for Refrigeration

WILL YOU please tell why sulphur dioxide is used instead of ammonia for small household refrigerating machines? As far as I can see, all the physical and thermodynamic properties favor the use of ammonia for this purpose, as well as in the large machines. What are some other refrigerants used in small machines?

C. N. R.

A. Since household refrigeration soon may offer appreciable power consumption, the National Electric Light Association in a report of its committee on Electric Refrigeration, offers considerable interesting information in Bulletin No. 25-48. In descriptions of a number of household refrigerators the majority are shown as using sulphur dioxide as a refrigerant although methyl chloride, ethyl chloride, isobutane, butane, ammonia and carbon dioxide are used in a few cases.

Due to its low critical temperature which is about 88 deg. F. and the high pressure required, carbon dioxide is restricted as a refrigerant. For ammonia the critical temperature is 266 deg. F. and for sulphur dioxide, 312 deg. F. With an evaporator temperature of 15 deg. F. and condenser temperature 70 deg. F., the condenser pressure, in pounds per square inch absolute, for carbon dioxide is 847; for ammonia it is 129; for sulphur dioxide, 50 lb.

It may be seen that carbon dioxide requires high pressure, necessitating forged steel compressor cylinders. This limits the size and therefore, the capacity of the compressor. Sulphur dioxide employs comparatively low pressures, but the volume of gas handled is about four times that required when ammonia is used.

In comparing sulphur dioxide with ammonia the entire refrigerating cycle with sulphur dioxide is carried on at comparatively low pressures. As previously stated, the use of amomnia as a refrigerant involves pressures upwards of 130 lb. per sq. in. and, in order to construct for household use a machine capable of sustaining these pressures, an unusually heavy and cumbersome apparatus would result. This would be undesirable, of course, from the standpoint not only of the manufacturer but also of the user. This point also involves the question of safety, since, if ammonia were used in a household refrigerating machine and, through some defect in manufacture, an accident should result, it might prove serious, both on account of the high pressures involved and on account of the ammonia gas itself. With the low pressures used in the sulphur dioxide machine, it is possible to design the apparatus with such a large factor of safety, and at the same time make it light enough for household use, that the foregoing condition is avoided.

Another reason for the use of sulphur dioxide in small refrigerating machines is that it is possible to use air cooling. This, of course, cannot be done with the usual ammonia refrigerating cycle and you can see that by the use of air-cooled condensers the manufacturer of the sulphur dioxide machine is able to simplify his design and reduce its weight to the lowest possible point.

It is true that from a purely thermodynamic standpoint, ammonia is superior to sulphur dioxide but for the reasons given, sulphur dioxide is used instead of ammonia for small household refrigerating machines.

As a matter of general interest in connection with household ice machines, it has been reported by the N.E.L.A. that a machine has been designed which does not use a liquid refrigerant, expansion of air in the compressor cylinders producing refrigeration which is transferred to the food compartment of the cabinet by means of vertical copper strips extending from the tops of the compressor cylinders. The transfer of refrigeration is entirely by means of conduction as no compressed air is allowed to escape from the cylinders. This machine is not being marketed at the present time.

Automatic Control Needed for Best Results

WE HAVE one 850-hp. Stirling type boiler operated with a multiple retort underfeed stoker, burning southern Illinois coal and controlled with a variable speed motor. The CO_2 in the last pass is 14 per cent and the air pressure in the main wind-box is 3 in. of water. The damper is kept closed to a point where the draft over the fire is just zero.

Now, when a load is put on the boiler, the steam pressure drops. The stoker then is speeded up, the damper opened several notches and the CO_2 drops to 9 or 10 per cent. The air pressure under the fire is not increased. Under these conditions, what changes take place in the furnace? Does it increase the combustion rate and also the steaming capacity of the boiler to open the flue damper, thereby causing a suction over the fire and lowering the CO_2 content?

W. F. D.

A. Passing by, for the time being, the advisability of operating as stated, it may be found that as the stoker is speeded up (it is assumed the grate bar motion also is increased), the CO_2 drops when the damper is opened because the draft over the fire is increased and more excess air enters the furnace. Notwithstanding the fact that more fuel is being put on the grate, the agitation at first causes larger orifices through the fuel bed, the air pressure in the wind-box is relieved more readily so that, instead of having a pressure of 3 in. it may drop to 2.5 in. This may cause the draft over the fire to increase from 0.00 in. to possibly 0.10 in. The draft in the uptake also may increase from 0.40 to 0.55 in.

If the stoker continues at increased speed for a certain length of time, however, and more and more coal is pushed in, the orifices in the fuel bed will be closed and, unless the fan is speeded up to give a greater air

supply, sufficient pressure will not be built up in the wind-box to break through the increased thickness of fuel. Let us consider a hypothetical set of draft conditions when operating as stated in your letter. Pressure in the wind-box may at first drop to 2.5 in. and then increase to 3.0 in. or even more, as the fuel gets thicker, but it will not be enough to break through.

The result will be that even if the stoker is stopped, the fuel bed may become so thick and the air flow retarded so much that the combustion rate is decreased. With less gas being produced over the fire, the draft will increase even beyond 0.10 in. In this case with a thick fuel bed, the air supply should be increased and fuel grate bars given some movement but no more fuel fed in for a certain time.

Feeding in more fuel may or may not increase the combustion rate with the existing air supply. It is a question of fuel bed agitation. Assuming that for a time it is increased, there will be more gas produced which tends to cause pressure over the fire. The damper should then be opened to give the *same draft* over the fire as previously. This may require moving the damper only one notch or even a half notch. If it is opened several notches, equilibrium is disturbed and the draft over the fire becomes greater than at first.

With more excess air going through the setting, the CO_2 will drop and then, even if the combustion rate is increased, the flue gas losses may be greater than the heat absorption and the steam pressure will drop.

This shows the inadvisability of operating as you have stated. Correct operation may be performed manually if the operator is alert but it is much more advisable to have automatic control. One of the simplest systems is that functioning by changes in draft over the fire and steam pressure. The operation of the flue damper to give variation in draft over the fire should work in connection with both the fan speed and stoker speed. If the load increases, the boiler pressure will fall. This will cause the stoker to speed up and also the fan, and at the same time the flue damper will open just enough to give the same draft over the fire as previously.

Where the forced draft fan is driven by steam, it is customary to install a standard pressure regulator operating a balanced throttle valve in the blower engine steam line, so connected up that the speed of the fan is controlled by the boiler steam pressure. That is, a drop in steam pressure automatically opens up the steam supply to the fan engine (or turbine) until the additional air from the fan has resulted in raising the steam pressure to normal, or vice versa.

In case the fan is driven by a variable speed electric motor, a special rheostat control is used, which also is governed by the steam pressure. By these means the steam pressure may be held approximately normal for the entire range of capacity. Where the fan prime mover consists of a constant speed motor, the air supply is regulated by a damper in the fan discharge. This damper can be operated by hand but a suitable pressure regulator is much more satisfactory.

For the small installations it is sometimes desirable to drive the stokers directly from the fan shaft by means of suitable shafting with sprocket and chain connections. In this case the speed of the stoker varies directly with the fan speed so that the supply of both air and coal is controlled from the boiler pressure.

Figuring Ash Pit Loss

IF COAL costs $5 per ton and analysis shows 10 per cent ash in the original coal and 25 per cent combustible in the refuse, what is the value of the ash pit loss?

L. P. H.

A. Before we can give you a definite answer to your problem, we should know the heat value of the coal. We can, however, assume a value of 10,000 B.t.u. per lb. dry basis. This will give you an idea of how to figure the problem so that, if your coal actually has 12,000 B.t.u. dry basis, you can divide the loss by 1.2 or by any other fraction over or above unity as expressed by the 10,000 B.t.u.

In the October 1, 1925 issue of Power Plant Engineering, p. 990, an article entitled "Simplifying the Boiler Heat Balance" contained information by which you could solve this problem. A formula was given for figuring the loss due to carbon in the ash when the refuse has not been weighed but an analysis has been made to determine the amount of carbon in it. This formula is as follows:

$$\text{Loss in B.t.u.} = \frac{C \times A}{1 - C} \times 14{,}600$$

where, C = per cent carbon in dry refuse; A = per cent true ash in dry coal.

You have not stated whether the 10 per cent ash is figured on a dry basis or not, but we will assume that it is dry. If it is not on a dry basis then, in order to get the correct answer, you will have to figure it to a dry basis if you know the amount of moisture in the fuel.

According to the above formula, the loss in B.t.u. equals

$$\frac{0.25 \times 0.10}{1.00 - 0.25} \times 14{,}600 = 0.033 \times 14{,}600 \text{ or } 487 \text{ B.t.u.}$$

If your fuel should contain 10,000 B.t.u. dry basis, then $487 \div 10{,}000 = 4.87$ per cent loss due to the combustible in the refuse. If your coal costs $5 per ton, then 4.87 per cent of this amount will be about 24 cents.

Heat Drop Determines Amount of Work

WHAT DOES the work in a prime mover, steam pressure or the velocity of the steam caused by the pressure? I have been contending that the velocity of the steam does the work, and that the pressure supplies the steam with the needed velocity.

J. B.

A. In a steam engine the work is done by a pressure acting against the piston. In a turbine the work is accomplished by velocity, either of the jet impinging directly upon blades as in an impulse turbine or acting reactively as in the case of a reaction turbine—the velocity of the jet in both cases being determined by the heat drop and not by the pressure. As shown by a Mollier diagram a drop of 125 B.t.u. is equivalent to a velocity of about 2500 ft. per sec. Starting with 250 lb. and 100 deg. superheat, a drop of 125 B.t.u. would bring the pressure down to about 58 lb. The next 125 would bring the pressure to 10 lb., and the next 125 down to 0.95 lb. per sq. in., so that as far as velocity is concerned the pressure drop from 10 to 0.95 lb. is just as good as a pressure drop from 200 to 58 lb.

EDITORIAL COMMENT

Can We Devise a Fair, Uniform Method of Comparing Bids?

Thirty-thousand kilowatt turbo-generators and centrifugal pumps rated at several million gallons a day are not bought like packing and Stillson wrenches. Such large units must be tailor-made, to a certain extent, to fit the particular conditions of each job. There is, of course, need for more standardization of units up to certain sizes, these sizes being determined by the conditions of the manufacturer's business, which is to make the best machinery he can at the lowest cost. Aside from this, however, considerable leeway must be allowed the manufacturer in making a unit to fit given conditions, as witness the differences in appearance and design of the turbines of different makes at certain large central stations.

In buying large turbines and similar machinery, therefore, the purchaser is confronted with a variety of equipment proposals submitted to him. The various makes of units will differ somewhat in structural details; the guaranteed water rates, efficiencies, and other performance data for the various units may vary somewhat or they may correspond closely, the latter condition being more frequent. How, then, is the purchaser, whether he is an engineer or not, to weigh the merits of the various proposals?

When all is said and done, the chief interest of the purchaser is in the cost of owning and operating a given unit. He knows, too, that the unit that has the lowest first cost is not necessarily the cheapest unit for him to buy. Too often, however, he does not know how to go about analyzing the differences in operating costs and fixed charges of several units of competitive make that may be submitted to him. Further complications are introduced by the fact that there seems to be no uniform basis in existence either among buyers of equipment or sellers of it, for making such comparisons. These comparisons, of course, should be made on a basis that will be just as fair to one as to the other.

Engineers should be interested, therefore, in the suggestions made by A. O. Miller in this issue in regard to methods of comparison of competitive proposals for equipment. In addition to bringing out the points noted above, Mr. Miller gives examples of evaluation of bids, together with a suggested method of calculating the operating cost of a pumping unit.

It is probable that the only satisfactory way of obtaining uniform methods of evaluation is that indicated by Mr. Miller; namely, for the engineering societies, acting as supreme technical authorities, to analyze the situation and to suggest methods equitable to all and based on sound engineering principles. The work that has been done by various engineering societies and associations in establishing test codes, definitions and specifications has been invaluable to the power plant field. If these organizations can take similar action in guiding buyers and sellers, especially of large units, they will merit the further thanks of the industry. The increasing interest in uniform standards of practice in all phases of engineering would seem to include this subject as well as those concerned purely with design and operation. After all, the prospective purchaser of equipment and the prospective seller of it are both more interested in C.O.D. than in B.t.u.

Business Papers and the Government

Repeatedly and with increasing frequency have the business papers been called upon to aid government departments and officials in bringing to the industries understanding of what the departments are doing and to help solve problems of policy and procedure.

At intervals, editors of business papers have met in Washington and conferred with cabinet officers and bureau heads as to business conditions, proposed changes and explanation of department purposes and methods. That the assistance of business papers is appreciated is evidenced by continuance of these conferences over a period of five years and the presence on numerous occasions of heads or high officials from every one of the Departments.

As was to be expected, the chief contact has been with Secretary Hoover of the Department of Commerce, since the work of his Department is more directly concerned with industry than that of others. In fact it was his initiative that brought about the start of these conferences.

On May 10, 100 business paper editors and publishers from all parts of the country met at the Metropolitan Club to commemorate the conclusion of 5 yr. of these memorable contacts, the circulation of papers represented being estimated at 2,000,000, of the cream of the industrial life of the country. After short addresses on the origin of the conferences and results achieved, a testimonial illuminated book was presented to Mr. Hoover expressing the gratification of the editors at the relationship which has existed and their appreciation of his confidence and of the confidential information that he has given.

In reply Mr. Hoover expressed his own appreciation of the help given him and stated that in the 5 years, although he has spoken freely and frequently to the business paper editors of matters that were of confidential nature, not once has the confidence been violated. He stated that results accomplished by his Department would not have been possible to the same degree without the co-operation and support of the editors.

This occasion and the previous meetings of the National Conference of Business Paper Editors with Government officials serve to emphasize the importance of

business papers in serving the industries and are a proof of the influence which they are exerting and the leadership which they have achieved in our industrial supremacy in the world.

Executives to Be Given Facts on Safety and Production

With increasing use of machinery in industry has come an increase in industrial accidents, notwithstanding the efforts of several organizations to impress upon workmen their responsibility in preventing accidents to themselves as well as to their fellow workmen. Safety in industry must come from the top of the organization. The owner of a plant who wishes to operate his equipment without accidents must see to it that his superintendents and foremen have an appreciation of the dangers encountered with the equipment and processes under their supervision. He will give them authority to provide safety devices and enforce rules of conduct among the workmen.

Unfortunately all men do not know all the chances for accidents which exist with the equipment they are operating. Every new device or machine presents individual problems in safety. From the scoop shovel to the mechanical coal conveyor is a long step mechanically but it is a still longer step mentally for the common laborer, whose capacity is measured by his scoop shovel job, to become the operator of a coal conveyor system. With the development of machinery must come also the development of the men who operate it. They must attain a certain knowledge of mechanics, strength of materials, electric circuits, heat transfer, pressures, friction, combustion, before they can even be admitted unguarded into a modern power plant.

Manufacturers and designers of machinery are continually improving their products making them more efficient, reliable and safe to operate. Many power plant devices are completely automatic, requiring only occasional supervision, nevertheless engineers are, for economic reasons, required to depend upon some laborers who, largely through ignorance, will take chances entirely uncalled for. Warning signs are not sufficient to prevent such accidents. Every day these laborers see engineers doing things which they are forbidden to do, going through gates labeled with a big red danger sign and operating switches and valves marked "Danger, Hands Off." In time they take no more heed of such signs than they do of the familiar "Spitting Prohibited" sign in public places.

According to the National Safety Council, 23,000 men and women were killed last year in accidents that took place in shops, factories and industrial plants. Accidents to the employes of only one great electrical corporation numbered 1988, which was a decrease of nearly 50 per cent from the total number during 1924. It is estimated that mechanical guards may reduce accidents 25 per cent but the elimination of the other 75 per cent depends largely upon arousing the interest and securing the cooperation of the individual workmen.

Safety, therefore, becomes a problem of management and as such the inspiration for safe practices must come from the head man in authority usually the owner or board of directors. That many of those in authority are dilatory in promoting safety is evidenced by the increasing number of accidents which occur throughout the country as a whole and the American Engineering Council is to be commended for its action taken recently to conduct a survey of industry to determine the relationship between safety and production. That safety pays dividends is the opinion of many who have put safe practices into industrial establishments and, believing the executive is the key to the situation, the present move is to arouse his interest by pointing out the economic advantages of accident prevention. In this work engineers can do much by furnishing data from plants under their charge.

Sending the Operating Engineer to School

Recently, in connection with the state convention of the National Association of Stationary Engineers, held at Purdue University, a laboratory short course for power plant operators was given for three days.

This course was intended to provide an opportunity for operating engineers to receive instruction in the fundamental problems encountered in their daily work. It began with a conference on power plant testing methods, instruments and apparatus, followed by an actual power plant test. After this the results of the test were computed and discussed in detail.

There was no enrollment fee and any engineer attending the convention who did not take advantage of this short course missed a splendid opportunity to increase his store of knowledge and to better his conditions.

Few colleges or universities in the country are so closely in touch with the needs of industrial enterprises and the problems of the workers as Purdue University. Its authorities are to be congratulated on their initiative and foresight in anticipating the need for better educated power plant engineers.

For years past Purdue has been one of the leaders in agricultural work and the same high grade of instruction extended to the farmer is now also being given to the power engineer.

Several of the large universities have extension courses, usually held at night, in various localities convenient to a number of men but the idea of bringing industrial operators directly into the campus should be even more beneficial. Here not only do they get the benefit of personal contact with high grade instructors but there is a certain psychological effect of the campus atmosphere which cannot be obtained elsewhere.

It would be an excellent plan, provided the universities themselves do not start the movement, for the leading industries in all parts of the country to arrange with their own state universities or other large schools, for short term summer courses in power plant engineering.

There may be as much money lost or saved in the power plant as in any other part of an industry and the comparatively small amount of money spent to pay the expenses of an operating engineer attending a short course in power problems, may be returned many times.

Every power plant owner or manager may find it profitable, from time to time, to send his operating engineers to school.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Ingersoll-Rand Condenser Features

SINGLE-PASS construction with comparatively small surface and high velocity of water through the tubes are the fundamental features of the condenser design illustrated below, which has been developed by Ingersoll-Rand Co. These features combined with a heart-shaped shell and tube spacing progressively closer from top to bottom, reduce volume of steam path as the steam is reduced, yet keep adequate cooling surface in contact with the steam.

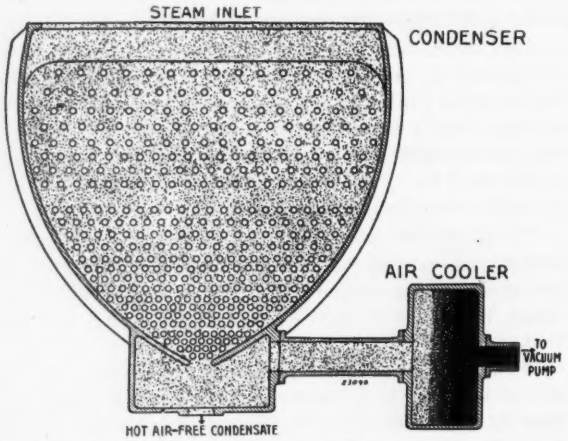


FIG. 1. HEART SHAPE OF SHELL AND STAGED SPACING OF TUBES MAINTAIN VELOCITY OF STEAM AS VOLUME DECREASES

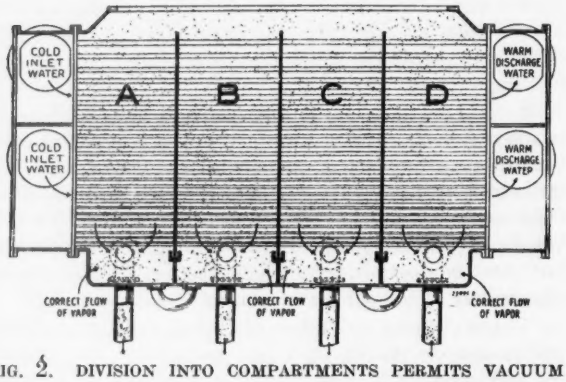


FIG. 2. DIVISION INTO COMPARTMENTS PERMITS VACUUM IN EACH SUFFICIENT TO PULL STEAM CLEAR THROUGH TO BOTTOM TUBES

The makers advocate condenser tests over long periods under working conditions to determine efficiency and capacity, and state that performance should be tested over a month's operation. Under such conditions, with heavy load, these condensers are stated to have condensed 11 to 14 lb. of steam per hr. per sq. ft. of surface as normal and for overload over extended periods to have condensed 17½ lb. or at the ratio of less than 0.6 sq. ft. per kw. of load. The vacuum was over 28 in. with cooling water at 70 deg. F.

Figure 1 shows the shape of shell, spacing of tubes and connection for removing air from condensate and cooling it separately. The reason for reducing the shell width and decreasing tube spacing is given as maintenance of steam velocity with shrinking volume and maintaining direct line flow to prevent stagnation and utilize all cooling surface. It is shown that cooling the air from 82 deg. down to 79 deg. before it is handled by the vacuum pump permits the size of pump to be cut in half with corresponding saving in power to remove the air. Further cooling to 72 deg. will reduce pump size to one-fourth that for 82-deg. air, yet the condensate has not to be cooled.

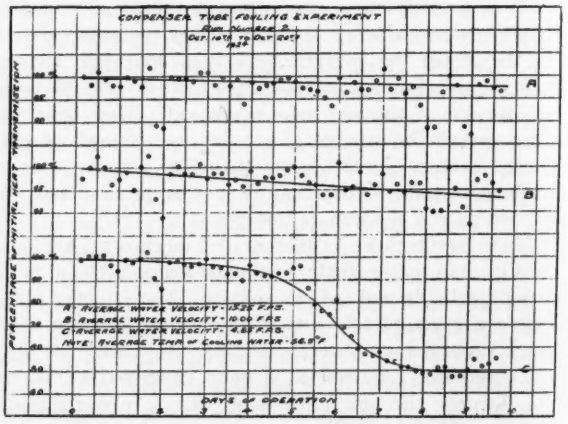


FIG. 3. HIGHER WATER VELOCITIES PRODUCE A SCOURING EFFECT WHICH DELAYS FORMATION OF SLIME ON INNER TUBE SURFACES

In the distribution lengthwise of the condenser, it is important to prevent collection of air at any one part as this results in ineffective action of the cooling surface at that part. By using steam-tight baffles to divide the shell into compartments and a separate vapor outlet for each compartment, as shown in Fig. 2, each section acts as a separate condenser in which a different vacuum can be maintained, if desired. This brings hot, active steam in contact with every part of every tube so that all water passing through the tubes carries away its quota of heat.

Rounded entrance, either with a bevelled tube edge or a bell-mouth tube is designed to aid in preventing corrosion and reduce friction loss as well as tube sheet foul-

ing because of the easier entrance of floating material into the tubes. For debris which cannot pass through the tubes, blowoff nozzles are provided opposite the water inlets so that the tube sheets may be cleaned without opening the water boxes and while the condenser is in operation.

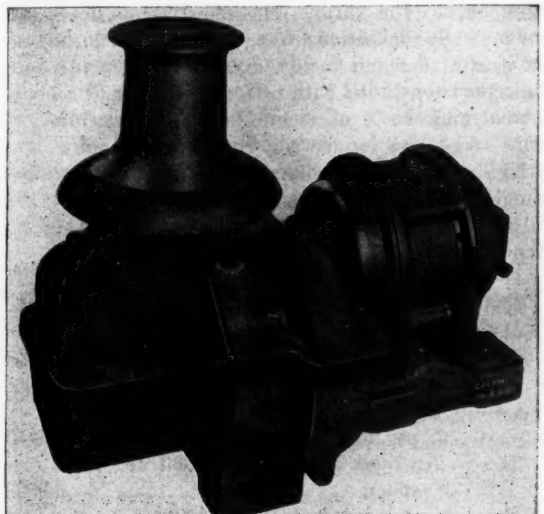
Prevention of slime and scale on the inside of tubes can be retarded by higher velocities as shown in Fig. 3, where curve A shows the fall in heat transmission over a 10-day period with water at 15¼ ft. per second, B for 10 ft. per sec. and C for 4.85 ft. per sec. average velocities.

Velocities of 8 to 10 ft. per sec. are obtained in these condensers with ordinary pump horsepower and, by closing off half the condenser, using full pump capacity, velocities of 15 to 20 ft. per sec. can be used for scouring at regular intervals.

Even for small condensers, the same features are used except that staging of tube spacing is not needed.

Small Car Spotter Built in Compact Design

DEMAND for a small, self-contained, compact car spotter has prompted the H. W. Caldwell & Son Co. of Chicago to place a new motor-driven, vertical capstan-type unit on the market. At present two sizes



GENERAL UTILITY OF THIS MACHINE INCREASED BY 360 DEG. WORKING RADIUS OF CAPSTAN

are available, No. 1 with a speed of 40 to 60 ft. per min. moving 1, 2 or 3 cars and No. 2 size with a speed of 26 to 42 ft. per min. moving from 3 to 6 cars.

Large upper bearing support allows the capstan to be mounted above the gearing and motor, as shown in the illustration, giving a 360 deg. working radius. Besides pulling and spotting cars, this feature permits wide application for moving materials in industrial plants.

Combinations of spur and worm gears are used with an automatic oiling system and it is said that 20-lb. pull on the capstan is sufficient to move a ton of weight on a straight track.

The low first cost, rugged design and general utility of this unit should make it popular in the smaller size power plants, where conditions do not warrant the installation of expensive and complicated equipment for this service.

Metal Center Packing for Piston Rods

AS SHOWN IN the accompanying illustration a new type of metal center packing, known as Garlock 377, has just been placed on the market. It is a lubricated, anti-friction metal packing with side walls, back and cushion of frictioned asbestos cloth.

SPECIAL DESIGN PRODUCES STAGGERED METAL SURFACES BEARING ON ROD

The metal core of this packing is manufactured from a solid piece of anti-friction metal. Special design produces a number of small metal surfaces so staggered as to give a pressure tight bearing on the rod. Diamond cuts in the metal impart flexibility to the packing, enabling it to encircle the rod closely. The small round punchings act as emission holes for the lubricant that is retained in the many folds of the metal.

The asbestos side walls and back hold the metal in place and the folded asbestos core above the metal is designed to act as a pusher and compensating cushion to bring the metal to the rod at an even pressure.

The ratio of wear on the bearing surface of the packing should be the same at all times on account of the square construction of the metal core.

Garlock 377, manufactured by the Garlock Packing Co., Palmyra, N. Y., is designed for service on the piston rods of main engines on steamships, deck engines, hoisting engines, steam shovels and dredges, steam hammers, kickers and steam niggers in the lumber trade and a general all around steam engine packing.

POTOMAC ELECTRIC POWER CO., of Washington, D. C., has authorized Stone & Webster, Inc., Boston, Mass., to design and construct an extension to its Bennings power plant which has at present a capacity of 120,500 kw. A 30,000-kw. turbo-generator, designed for stage extraction feed water heating, operating at a steam pressure of 350 lb. and 700 deg. F. total temperature, will be installed. The existing station is operated with a steam pressure of 180 lb. and the new unit will be the first step toward higher operating pressures in order to obtain greater efficiency. Four boilers will be installed having a capacity of 1400 hp. with inter-deck superheaters, water cooled furnace walls and air preheaters.

N. D. H. A. Holds 17th Annual Convention

PROMINENT HEATING ENGINEERS READ PAPERS ON FIN-TUBE FURNACE, AIR PREHEATERS, INVESTMENTS AND COSTS, DISTRIBUTION SYSTEMS AND OTHER SUBJECTS AT NIAGARA FALLS MEETING

AT NIAGARA FALLS, N. Y., from June 1 to June 4, the National District Heating Association held its 17th annual convention, with a large attendance, enthusiastic meetings and a program of addresses, committee reports and discussions that brought out valuable data.

Thomas E. Murray, in a paper on the fin-tube furnace, called attention to the way in which power plant costs have been increasing, due partly to the race for efficiency in boiler operation and the resulting large boilers and furnaces used. Maintenance of refractories was a large item in this increasing cost and the fin-tube furnace wall was an attempt to eliminate refractories. The great success obtained with it led later to the development of a new type of boiler consisting of a furnace the walls of which are of fin-tubes in which the steam is generated. The increased capacities thus made possible and the decrease in space ought to lead to greater economies in steam generation, Mr. Murray said.

PULVERIZED COAL AND FUEL OIL USED IN SOME STATIONS

Pulverized coal equipment in district heating stations was described by F. A. Guenther, discussing the Cecil plant of the Allegheny Steam Heating Co. and by R. F. Bohn, describing a plant of the Illinois Electric Power Co. In the latter plant, much coal dust is eliminated by keeping the entire coal conveying system under suction except a duct from the mill exhausters.

D. Caleb, in his paper on The Use of Fuel Oil by a Central Heating Station, discussed first the general oil situation and then described in detail the methods used for burning oil in a central heating station which was designed in 1907. Burners of large capacity—two or three of 350-hp. rating each to each 500-hp. boiler—are used to minimize clogging. Burner control valves are made with square openings formed by two 90-deg. V-shaped openings, one moving across the other, and have been run for hours without clogging. Smoke indicators are provided for the operators. This plant maintains an over-all efficiency, after crediting 5½ per cent to atomization and blow down, of 70 to 73 per cent over a month's operation; this figure does not compare, of course, with that of a modern plant, but seems fair for a plant designed in 1907.

REPORT OF TESTS ON AN AIR PREHEATER

Effect of Air Preheaters on Boiler Room Economy was treated by W. A. Herr. An interesting set of diagrams showed the results of tests on a tubular type air preheater applied to a 1422-hp. Stirling boiler with a 5250-sq. ft. Stirling economizer. These curves showed that as more surface is added to the preheater, the temperature of the leaving air, for a given flow, approaches the temperature of entering gas. They also showed that as the surface was increased, the total losses through the boiler and preheater decreased, but the losses on the air side of the heater increased. As the surface is increased, the cost of boilers, superheaters and stokers remains constant, cost of building, ducts and preheaters rises, cost of fans and auxiliary turbines diminishes, thus the total yearly carrying charges increase. Total yearly cost curves show that the relative cost with larger heaters falls to a minimum and then rises; that the relative cost for any particular preheater becomes less the more hours per year it is operated; that larger preheaters are needed for greater economy as the number of hours of operation is increased.

F. P. Wilson described an interesting method of removing slag from boiler tubes by blowing with cold water instead of steam.

ANALYSIS OF COSTS, OPERATING STATISTICS AND DESIGN OF DISTRIBUTION SYSTEMS

In the report of the committee on rates and regulations, comparison was made of investment in production and distribution systems in both steam and electric utilities. It was stated that this distribution per dollar of gross income, computed from the latest data, was as follows:

Utility—	Unit Investment	Production	Distribution
Electric	$4.48	$1.59 to 1.79	$2.68 to 2.92
Steam	3.50	2.52	0.98

These figures, the report states, indicate that the problem of the electric utility is to reduce transmission and distribution investment, whereas the problem of the steam utility is to reduce production investment. Interesting curves for various classes of steam loads were shown, while definitions were given of such terms as load factor, demand factor, diversity factor and so on. The report concluded with a tentative draft of a method of analyzing costs of steam heating companies, with forms and tables for distribution of the accounts.

The report of the committee on operating statistics brought out, among others, the following data for 1925:

No. of Co.'s Reporting		
37—	Customers	10,627
33—	Total boiler hp.....	194,242
21—	Electricity generated, kw-hr...	145,030,096
35—	Steam sold 1000 lb.....	15,055,763
26—	Annual load factor, average...	21.6%
17—	Average evaporation steam sold per lb. of coal burned.....	6.65
34—	Average income per 1000 lb. steam	$0.826

Fundamental points to be considered in the design of a steam distribution system were discussed in detail by the distribution committee. These points were: general plan and survey; transmission line pressure and load factor; high pressure feeders; initial pressure variations; types of underground construction.

Advantages of Welded Piping in District Heating Work were treated by A. W. Moulder, who referred to his previous paper on Gas Welding of Power Plant Piping in Shop and Field. The Indianapolis Light & Heat Co. described its method of controlling the heating supply by means of a long-distance recording pressure gage.

Illustrated by motion pictures, a symposium on Recent Developments in and Future Trend of Central Station Heating was held, with addresses and papers by James D. Hurd, J. H. Walker, C. H. Day, W. W. Stevenson, R. R. De Wolf and L. E. Young.

Plans Announced for Fifth New York Power Show

PRELIMINARY plans for the Fifth National Exposition of Power and Mechanical Engineering indicate that the coming event, which is to be held in the Grand Central Palace, New York City, from Dec. 6 to Dec. 11, 1926, will be even larger and more inclusive than the Fourth Exposition.

Three entire floors of the Palace have been sold to exhibitors and a portion of the fourth floor. Contracts have been signed with 332 manufacturers of all types of mechanical and power plant equipment. At the previous show, about 140 exhibitors showed products that are of importance to the heating and ventilating field and 75 showed machine shop equipment. The total number of exhibitors was over 400, and while a large number devoted space to power generating equipment, the entire show gave a great deal of exceedingly valuable new information of general interest to all types of industry.

An important innovation in the conduct of the coming exposition will be the addition of several exhibits essentially educational in character, which point out the tremendous advances that are being made in mechanical design and construction.

The exhibition managers are assisted in the conduct of the exposition by an Advisory Board made up of representatives of technical societies in the mechanical field and also representatives of large users of mechanical equipment who are interested in maintaining the high standing of the exposition. I. E. Moultrop, Edison Electric Illuminating Co. of Boston, is chairman of this board. The managers of the Exposition are Charles F. Roth and Fred W. Payne of the International Exposition Co., Grand Central Palace, New York, to whom all inquiries should be addressed.

Bucks Creek Hydro Plant to Have Highest Head in U.S.

OPERATING under a head of 2552 ft., only 88 ft. less than a half mile, a hydro-electric plant which is being constructed on Bucks Creek, in Plumas County, Calif., by the Feather River Power Co. will operate under the highest head yet used in the United States. An unusual feature of the project will be the ratio of storage capacity to yield. At the main Bucks Creek reservoir there is an estimated annual run-off from the water sheds above the dam of 72,000 acre-feet. In order to control this run-off, a storage capacity of 103,000 acre-feet will be provided. The average total yield through the power house will be 114,000 acre-feet per year, and this will produce 205,000,000 kw-hr.

To form the storage basin, the dam will be constructed in the wide mouth of Bucks Meadows. It will be 1220 ft. long on the top, will rise 118 ft. above the stream bed and will be of the rock-fill type. The power house will be on the east, or left, bank of the river. The main building will be 105 ft. long, 45 ft. wide and 45 ft. high. In addition, an indoor switch cell room, 70 by 30 ft., will be constructed on the mountain side of the main power house. The slope of the mountain is gradual enough to give the required space without excessive excavation.

Power will be generated by two General Electric 25,000-kv-a., 450-r.p.m., 11,000-v. waterwheel-driven generators. Other electrical equipment necessary for this station, supplied by the General Electric Company, includes two motor-generator sets; seven 8333-kv-a., 240,-000/11,000-v., single-phase, water-cooled transformers; seven station lighting transformers; six 2000-amp., truck-type oil circuit breakers; a large switchboard and miscellaneous material.

Another hydro-electric station operating under an extremely high head—second only to the Bucks Creek station—is the Balch Plant on Kings River, of the San Joaquin Light and Power Corp., with an ultimate static head of 2470 ft. The proposed design of this project was discussed in detail in the April 1, 1926 issue of Power Plant Engineering.

United Electric Light Co. Opens New Station

AT BRADDOCK, PA., the new $800,000 generating station of the United Electric Light Co. was opened on May 24, when a dinner attended by the industrial and power plant leaders of the Pittsburgh district was served in the turbine room of the building. The new station, which at present has a capacity of 6250 kv.a. but which has been designed for an ultimate capacity of 12,500 kv.a., will serve an area of 40 sq. mi. with a population of 43,000 people.

Present equipment of the station includes three Edge Moor boilers, fired by Westinghouse stokers and operating at 250 lb. steam pressure, with 125 deg. of superheat. Two 3125-kv.a. Westinghouse steam-turbine-driven generators and Westinghouse surface condensers are installed. One boiler and one turbine are held in reserve for standby service. There are also extra transformers and a duplicate transmission line. Power will be generated at 6600 v., three-phase, 60 cycles. This will be stepped up to 22,000 v. for transmission and stepped down to 2200 v. for distribution.

The building has been so constructed that floods from the Monongahela River cannot damage it. It is of concrete and steel, a fireproof construction, throughout, with a cement tile roof and asbestos protected side walls.

New Museum to Portray Industrial Development

SUBSTANTIAL PROGRESS is now being made with plans for a great industrial and technical museum soon to be established in New York, under the will of the late Henry R. Towne. It is to be known as the Museum of the Peaceful Arts, of which the president is Dr. Geo. F. Kunz and the honorary secretary is Calvin W. Rice. The purpose of the museum is to show the development of basic industries from the early handcrafts to the present time. It is to be established primarily for the layman in order to introduce him to the subject rather than to lead him on into highly specialized research. Original material will be utilized wherever procurable and suitable and as many models as

possible will be used. The first section of the museum, at the suggestion of Mr. Towne, will probably be that of machine tools and shop practice, since this field is fundamental to all other industrial arts. Many specialists are now at work in this country and in Europe, formulating plans for the exhibits, searching for the proper equipment and enlisting co-operation of the great industrial firms of this country.

News Notes

THE AMERICAN FARM BUREAU FEDERATION has just issued a statement opposing the bill of the joint congressional committee introduced in support of the proposal for the Muscle Shoals properties made by the associated Southern power companies, as reported in the June 1 issue of Power Plant Engineering. The federation makes five major objections and six others. It opposes divided responsibility between nitrate and power production and states that there is no definite guarantee to produce the fixed amount of fertilizer; that the process to be used is experimental; that the cost of power will be high because of the high bid; and that no amortization provision has been made in the lease. The statement is also made that the companies are unfamiliar with fertilizer production and that their interest lies primarily in power generation and that if they can pay the government more than any other group it is because the payment will be regained from their customers.

THE GENERAL PUBLIC UTILITIES CO., recently organized under the Florida laws, will take over and operate a number of important utilities in the south and west, including Southwestern Public Service Co., Gulf Public Service Co., Consolidated Power and Light Co. of South Dakota, Nebraska Light & Power Co., and others. Several new steam power plants will be constructed, together with new transmission lines in the various parts of the systems and several ice plants. The properties will all be under the management of Day & Zimmerman, Inc., Philadelphia, Pa.

THE UNITED ELECTRIC POWER CO. has been chartered by the Rhode Island Legislature. The United Electric Railways had a power plant but when it suspended trolley operations, found the plant to be much too large for its needs. Under the new charter the company, which takes a new name, will be permitted to dispose of this surplus power. The right is given the new company to purchase the railway company's power plant and to resell it if it so desires. The new company will operate only for wholesale distribution of power and will not compete in retailing with the Narragansett Electric Lighting Co.

THE BOARD OF TRUSTEES, PRINCETON UNIVERSITY, Princeton, N. J., is perfecting plans for the early erection of a new school of engineering to cost about $650,000, with equipment. It will include a mechanical engineering laboratory, electrical laboratory, machine shop and all necessary facilities for the mechanical and engineering departments. Day & Klauder, Philadelphia, Pa., are the architects.

THE LARGEST ELECTRICAL TRANSFORMER ever built, for experimental purposes, has been shipped from the General Electric Co.'s plant at Pittsfield, Mass., to the Leland Stanford University at Palo Alto, Cal. It has a rated voltage of 2,100,000, or twice as great as anything previously built and a third greater than the lightning machine which was used by the General Electric Co. for its experiments in man-made lightning.

Allen B. Hendricks, electrical engineer, had charge of its construction. At Leland Stanford University, Professor Ryan, former president of the American Institute of Electrical Engineers, will have charge of the experimental work. The transformer will be housed in a steel building located in a 100-acre tract. The transformer throws a 20-ft. arc, cost about $500,000 and required 100 mi. of wire in the windings for the cores. It weighs about 45,000 lb.

ERIC N. NELSON, Ohio Public Service Co., Warren Power Station, has been transferred to the Mansfield Plant, Melco, O., as results engineer.

W. G. BURRILL of Bangor, Me., who has been associated with the Bangor Hydro-Electric Co., has resigned to become commercial manager with the Staten Island Edison Electric Co.

ILLINOIS STEEL CO., Gary, Ind., operates two Harrington stoker installations under steam boilers in which coal is burned under one end and either gas or oil under the other end.

BOTFIELD REFRACTORIES CO., Philadelphia, Pa., has appointed the Standard Asbestos & Cork Co., Tulsa, Okla., as distributor of its product, Adamant fire brick cement.

R. H. BEAUMONT CO., Philadelphia, Pa., announces the opening of a western branch at 1544 Straus Building, 310 South Michigan avenue, Chicago, in charge of H. E. Birch, formerly sales manager at Philadelphia.

BRIDGEPORT BRASS CO., Bridgeport, Conn., announces that H. Allen Faust, its representative in Pennsylvania and southern New Jersey, will also represent it in Maryland, West Virginia and Washington, D. C.

THE CECIL R. LAMBERT CO., INC., Detroit, specialists in the design, manufacture and installation of conveying and handling equipment announces that its name has been changed to Mechanical Handling Systems, Inc.

WARREN WEBSTER & CO. announces the appointment of Lucien J. White as district manager of its San Francisco branch office and of Rushby C. Midgley as district manager of the branch office just opened in Salt Lake City, Utah.

RILEY STOKER CORP. has recently installed two Atritas of 5000 lb. per hr. capacity each at the plant of the Wisconsin Power & Light Co., Sheboygan. Operation of these was scheduled to begin in the week of May 9. Sargent & Lundy, Inc., Chicago, are engineers for this work.

YEOMANS BROTHERS CO., Chicago, Ill., manufacturers of sewage ejectors and pumping machinery has just appointed the General Equipment Co., Lafayette Arcade Bldg., Tampa, Fla., as its sales representative for central and southern Florida. The office of the General Equipment Co. is in charge of Eugene F. Leger, treasurer, assisted by H. L. Knowlton, sales engineer.

THE TIMKEN ROLLER BEARING SERVICE & SALES CO., announces the appointment of H. E. Gilmore as manager of the St. Louis branch and the promotion of G. W. Curtis from industrial equipment engineer to district manager of sales, industrial division, for the Milwaukee

territory. Mr. Curtis is succeeded as industrial equipment engineer by Mr. Weckstein. Announcement is also made that the Omaha branch office of The Timken Roller Bearing Sales & Service Co. has been moved to 2240 Douglas St., and the Los Angeles branch is moving to 1361 South Figueroa St.

THOMAS E. MURRAY, INC., New York City, announces that it is now proceeding with the design of the new steam generating plant for the New York Steam Corporation. The first unit will contain three boilers, each with a capacity of 325,000 lb. of steam per hour.

BERNITZ FURNACE APPLIANCE CO., Boston, Mass., announces that E. G. Schlayer, sales engineer, has just resigned to accept a position in the service and erection department of Combustion Engineering Corp., New York.

THE FITKIN UTILITIES CO., New York, has concluded negotiations for the purchase of the Georgia-Florida Power Co., and its subsidiaries known as the Seminole Power Co., and the Bainbridge Power Co., serving towns in southwestern Georgia and northern Florida.

ISSUANCE OF A preliminary permit to Dexter P. Cooper, Inc., of Eastport, Me., covering the proposed development of tidal power in Passamaquoddy and Cobscook Bays, in Washington County, Me., has been authorized by the Federal Power Commission.

AT THE ANNUAL business meeting held in the Engineering Societies Building, in New York, on Friday, May 21, by the American Institute of Electrical Engineers, Cummings C. Chesney, manager and chief engineer of General Electric Co., Pittsfield, Mass., was elected president.

THE SYNDICATE POWER CO., Dallas, Texas, has been granted permission by the Texas State Board of Water Engineers to construct six power dams on the Colorado River between Austin and San Saba, Texas. These plants will have an aggregate output of 122,700 hp. and will probably cost about $20,000,000 with the transmission system.

BATES & ROGERS CONSTRUCTION CO. has been awarded contract for the masonry construction on the new addition to the Crawford Avenue plant of the Commonwealth Edison Co. This addition will practically double the capacity of the plant. The masonry contract, which runs to over $1,000,000, will be in charge of Leonard Childs, engineer of Bates & Rogers, for power plant construction.

CONSTRUCTION OF A SECOND LINE of 66 kv. and about 14 mi. long from its Somerset Station to connect with the lines of the Edison Electric Illuminating Co., of Brockton, has been authorized by The Montaup Electric Co. A 7500-kv.a. synchronous condenser will be installed in an extension to the present switch house for voltage control and power factor correction. Stone & Webster, Inc., Boston, Mass., is to design and construct this new line.

SALES BY THE WESTINGHOUSE ELECTRIC & MFG. CO., for the year ending March 31, 1926, totaled $166,006,800, as shown by annual report which has just been mailed to its stockholders. This represents the largest volume of business in the company's history. The cost of sales was $151,700,000. After adjustments to cover other income, charges for interest, etc., the net income available for dividends and other purposes was $14,122,001 or 11.9 per cent on the total capital stocks of $118,503,150. The value of new orders booked during the year also shows a substantial increase over the previous year. After adjustments, the value of unfilled orders at the end of the fiscal year was $55,163,247. The total of all payrolls for the year was $74,144,607, equal to about 49 per cent of the cost of sales billed.

THE TIMKEN ROLLER BEARING CO., announces that $1,500,000 will be spent in expanding its Canton plant to provide enlarged laboratory, research and manufacturing facilities to care for the increased demand for Timken bearings.

APPLICATION FOR THE LICENSE to build a 40,000-hp. hydro-electric plant on the Cumberland River, near Cumberland Falls, Ky., has been filed by the Cumberland Hydro-Electric Power Co., of Indianapolis, through Robert G. Gordon, of Louisville, Ky.

CARTER WHITE LEAD CO., West Pullman, Ill., is at present burning 5/8-in. to 3/4-in. chestnut coke on two 5 ft. by 12 ft. Harrington Stokers carrying an 11½-in. fuel bed. This is the first time that this large size of coke has been burned on chain grate stokers. The CO_2 averages 12.5 per cent and is used in paint process work.

THE ROCKLAND LIGHT & POWER CO., Nyack, N. Y., has secured permission to carry out its proposed merger with the Rockland Light Co., Orange County Public Service Corp., and the Catskill Power Corp., the consolidated organization to be known as the Rockland Light & Power Co., Expansions and improvements in power plants and transmission lines will be made.

SAVANNAH ELECTRIC & POWER CO., of Savannah, Ga., controlled by the Engineers Public Service Co., has authorized Stone & Webster, Inc., Boston, Mass., to design and construct an extension to its Riverside Power Station. This will contain a 15,000-kw. turbo-generator, a 27,000-sq. ft. condenser with auxiliaries and two pulverized-coal-fired boilers of 1370 hp. each, with water-cooled walls.

THE INTERNATIONAL PAPER CO., Bellows Falls, Vt., is tearing down part of its mills there for the purpose of reconstructing the canal and for the purpose of erecting a new power plant. The power capacity of the plant will be increased from 19,000 hp. to 45,000 hp. The work of building the power plant will be under the direction of the New England Power Construction Co. and it is expected that the development will take from 2 to 3 yr. to complete.

ELMER E. HAUER, head of the Hauer Power Equipment Co. of Cincinnati, Ohio, died on May 23rd, at his home in Springfield, Ohio, at the age of 65 yr. Mr. Hauer had been engaged in the manufacture, design and sale of power plant equipment for more than 20 yr. He was, for 16 yr. connected with the Lagonda Mfg. Co. of Springfield, Ohio and later, with his son, B. T. Hauer, established the company which bears his name. He took out 45 patents at various times, many of which cover equipment now being manufactured in the power plant field, the most recent being the development of the multiduct strainer, manufactured by the Blackburn-Smith Corp.

Catalog Notes

ERIE BALL ENGINES installed in all types of modern power plants are attractively illustrated in a bulletin just issued by the Erie Ball Engine Co., Pittsburgh, Pa.

LACLEDE-CHRISTY BULLETIN for April, 1926, published by Laclede-Christy, St. Louis, Mo., contains an interesting article on the consumption of refractories in various industries that use furnaces of all types.

DEAN HILL PUMP Co., Anderson, Ind., has recently issued circular No. 402, which describes in detail the construction of the company's double suction centrifugal pumps.

THE IRON FIREMAN, an automatic coal burner for industrial plants and heating systems and for high and low pressure boilers up to 200 hp., is described and illustrated in a folder issued by The Iron Fireman Mfg. Co., Cleveland, O.

"AN EPOCH MAKING DISCOVERY" is the title of a folder recently issued by the Bakelite Corp. of New York City. This folder tells the story of Bakelite in an interesting manner and enumerates the uses to which this material is put.

WORM GEAR SPEED REDUCERS are described in bulletins 251 and 261 recently issued by the Horsburgh & Scott Co., Cleveland. The bulletins contain detailed description of the various parts of the speed reducer, together with illustrations of details and of applications.

THE UEHLING INSTRUMENT Co., Paterson, N. J., is distributing a new catalog, No. 150, covering its combined pyrometer and vacuum recorder for use with steam turbines. The bulletin also includes valuable turbine performance data, typical charts, sectional views and dimension diagrams.

ALLEN-BRADLEY ELECTRIC CONTROLLING APPARATUS is described in a group of bulletins issued in an attractive binder by Allen-Bradley Co., Milwaukee, Wis. These bulletins give dimensions, details and applications of d. c. and a. c. manual and automatic starters, rheostats, battery charging equipment and the like.

THE GENERAL ELECTRIC Co., Schenectady N. Y., has recently issued Bulletin GEA-178 on the subject of instrument transformers. This bulletin is in reality a detailed technical article on the subject of instrument transformers. It comprises 52 pages and is devoted to the theory and engineering characteristics of transformers used to facilitate the measurement of electrical qualities.

It is profusely illustrated with photographs, diagrams, charts and tables. An idea may be obtained of the subjects covered from the following list of chapter headings: Description, Errors and Accuracy, Secondary Burdens, Tests, and Miscellaneous. An appendix giving burden data, phase angle, correction factors and characteristic curves is included at the back of the book.

REPORT OF THE REFRIGERATION COMMITTEE, Commercial National Section of the National Electric Light Ass'n for 1925-1926, calls attention to valuable information contained in last year's report and states that nothing extraordinary or new in principle has appeared during the year: Manufacturing facilities have been extended and the organization of the Electric Refrigeration Manufacturers Council should be a stabilizing influence. Discussion of the value of refrigeration business to the central station is included. Emphasis is placed on education in basic principles of refrigeration and consideration is given to policies of utilities companies operating both electric and ice manufacturing plants.

THE NATIONAL RESEARCH COUNCIL, 29 West 39th St., New York City, has just issued "A Bibliography on Research," citing selected articles from the technical press which appeared during 1923, '24 and '25. The general distribution of this bibliography will be made to industrial research laboratories, trade associations, technical colleges, universities and libraries.

SPECIAL PUBLICATION 1643-A describing the application of oil circuit-breakers has just been released by the Westinghouse Electric and Manufacturing Co. It describes fully the general application of oil circuit-breakers, the determination of short-circuit current, and the precautions necessary, and devotes a number of pages to tables and charts. Several interesting halftone illustrations are also included.

BROWN PYROMETERS is the title of Catalog 15, just issued by The Brown Instrument Co., Philadelphia, Pa. The catalog is most attractive, with 120 illustrations, some in five colors, and the latest information on Bureau of Standards tests of Brown Pyrometers, Brown New Design Recorders, the New Moisture-proof Rotary Switch, the New Champion Sillimanite Thermocouple Protecting Tubes, and complete description of Brown Pyrometers of all types. Discussion of manufacturing processes in the Brown plant is of interest.

TESTS OF A CLEVELAND WORM GEAR REDUCTION UNIT designed to transmit 125 hp. from a 3200-r.p.m. steam turbine to a 300-r.p.m. fan installed in one of the plants of the Lynn Gas & Electric Co., Lynn, Mass., are described in Survey No. CK-16-AR, issued by A. C. Nielsen Co., Chicago. The survey also describes tests on a Cleveland reduction unit with a 9¾ to 1 ratio on a main stoker drive shaft in the same plant. The reduction units were furnished by the Cleveland Worm & Gear Co., Cleveland, Ohio.

FRAHM VIBRATING-REED TACHOMETERS are described in catalog 1120 and Dionic Water Testers are described in bulletin 1125, recently issued by James G. Biddle, Philadelphia, Pa. Catalog 1120 discusses the principle of operation of the Frahm Tachometers, gives in detail construction of the instruments and illustrates various types with their applications. The Dionic Water Tester, while not new in the field is new in form, as described in bulletin 1125. Details of the instrument are given, followed by a discussion of practical uses of the tester.

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES, 1925, just published by the Geological Survey of the Department of the Interior, is one of a series of annual reports that includes short papers on the water resources of different parts of the country. It contains a paper on water power irrigation in the Madison River basin, Montana, a paper on the chemical character of the ground water of the northern Great Plains, a preliminary report on the geology and water resources of the Mud Lake basin, Idaho, and an index of analyses of natural waters in the United States. All these papers have previously been published separately but are now issued in a single volume, designated Water-Supply Paper 560. A copy can be obtained by writing to the Director of the Geological Survey, Washington, D. C.

Sparks from the Advertising Pages
Where Buyers and Sellers Meet

"What Shall the Harvest Be?"

Drawn from the earth by the warmth of an ascending sun, enriched by elements from soil and air, streams of sap flow upward and from tiny seeds and mighty trees the earth is clothed with a new verdure.

By these springtime sights and odors we realize that Nature's mighty production forces are again in full swing and we know that in a few short months another great harvest will provide the materials for food and clothing; moreover that millions of dollars of new wealth will have come into being.

In the meantime, walls are rising on newly set foundations for hundreds of new power plants to be completed and filled with new machinery and equipment, ready to take up the increased demand for power, heat and light next fall and winter.

Hundreds of other plants are being projected in executive committees, provided for in financial houses, shaped on drafting boards, to keep pace with the foreseen requirements of another year's harvest and the countless processes of its manufacture.

Progress in engineering science is moving forward in great strides to meet the demands for greater service.

These two mighty factors are upbuilding plants, giving men greater opportunities in both operation of plants and designing of machinery. They are making mechanical power more and more the fundamental basis of progress in every home, factory, building and business throughout the country.

A hundred and ten million people are discovering the convenience, leisure, increased earning capacity and freedom from drudgery that power is ready to give them more and more abundantly.

Swiftly, silently, well-nigh unnoticed by the vast majority of the people who are themselves in this march of progress, every part of modern life is moving onward and upward at a rate never before approached in human history.

In the power plant field every man may well ask himself, "What will the harvest be?"

Every increase in mechanical efficiency broadens the market for power; every personal experience in the better use of power and light spreads the demand and increases the desire for greater profit and convenience by its use. Every contribution of power to making better or cheaper products from earth-drawn resources, boosts the demand for such products.

These cycles are bound to go on, around and around with the years, and continuously upward and upward, because they are working for a better and more abundant life for every man, woman and child throughout the country.

Prepare now for the immediate harvest and those harvests of the ever-broadening future by improving and increasing plant and mental equipment with the information given in these pages.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allen & Billmyre Co., Inc., New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Nordberg Mfg. Co., Milwaukee.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros Co., Chicago.

AIR FILTERS.
Allen & Billmyre Co., Inc., New York.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.
New York Blower Co., Chicago.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Williams Gauge Co., The, Pittsburgh.
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Burke Engineering Co., Holland, Mich.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hoffi Co., The M. A., Indianapolis, Ind.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.
Hagan Co., George J., Pittsburgh.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Hagan Co., George J., Pittsburgh.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.

BABBITT METAL.
Magnolia Metal Co., New York.

BEARING METAL.
Magnolia Metal Co., New York.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT DRIVES.
Smidth & Co., F. L., New York, N. Y.

BELTING.
New York Belting & P'k'g Co., New York.
Pioneer Rubber Mills, San Francisco
Quaker City Rubber Co., Philadelphia.
United States Rubber Co., New York, N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Air Preheater Corp., The, New York.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
New York Blower Co., Chicago.
Terry Steam Turbine Co., Hartford, Conn.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER COVERINGS.
Celite Products Co., New York.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.
Scaife & Sons Co., Wm. B. Pittsburgh.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SEAM PROTECTORS.
National Boiler Protector Co., Dayton, Ohio.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.

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Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
New York Blower Co., Chicago.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Allen & Billmyre Co., Inc., New York.
Sturtevant Co., B. F., Hyde Park, Mass.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, STEAM.
Schutte & Koerting Co., Philadelphia.

BLOWERS, TUBE.
Diamond Power Specialty Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Sherwood Mfg. Co., Buffalo, N. Y.

BLOWERS, TURBINE.
Allen & Billmyre Co., Inc., New York.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CASING.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chemical Co., Inc., New York.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison-Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.
Sherwood Mfg. Co., Buffalo, N. Y.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor, Del.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Nuway Boiler & Engineering Co., Chicago.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw.

BOOKS AND SCHOOLS.
McGraw - Hill Book Co., Inc., New York.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO AND MOTOR.
Calebaugh Self-Lubricating Carbon Co., Inc., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Fuller - Lehigh Co., Fullerton, Pa.
Hills - McCanna Co., Chicago.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT GUNS
Cement-Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Johns-Manville, Inc., New York.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS.
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.